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CARRYING CAPACITY FOR BALD EAGLES WINTERING ALONG A NORTHWESTERN RIVER

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ABSTRACT.—Numbers of Bald Eagles (*Haliaeetus leucocephalus*) wintering along the Skagit River, Washington, in a 7-year period were correlated with estimates of numbers of Chum Salmon (*Oncorhynchus keta*) returning to the river to spawn, and inversely associated with daily water flows and average numbers of flood days in January and February. Available salmon biomass, measured every two weeks along 43 km of river, was in surplus of eagle requirements from 24 November 1980 through 4 January 1981, but in deficit thereafter in the same winter of close study. Recruitment of fresh Chum Salmon carcasses continued until mid-January, after which slowly receding river levels exposed additional carcasses. Coho Salmon (*O. kisutch*) spawning in tributaries then became a major food source. We tagged 214 live post-spawn Chum Salmon at spawning sites and we estimate from recoveries that about 13% became available to eagles. Predictions of local carrying capacity for eagles based on salmon escapement figures, the availability index of 13%, and daily food requirements of Bald Eagles showed remarkably close fits with actual numbers of eagles supported by both the entire Skagit River drainage and an intensively studied subunit. A sample of eagles fitted with radio transmitters traveled west from the Skagit and Nooksack rivers to Puget Sound, where visual surveys showed increases in eagle numbers during January and February, corresponding with decreases on the rivers.

Capacidad de mantenimiento de la zona para el Águila Cabeciblanca que inverna a lo largo de un río del norte

EXTRACTO.—Las cantidades de Águilas Cabeciblanas (*Haliaeetus leucocephalus*) que invernaban a lo largo del río Skagit, Washington, en un período de 7 años, fueron correlacionadas con números estimados de peces salmón de la especie *Oncorhynchus keta* que retornaban al río para desovar. Estas cantidades de águilas también fueron inversamente correlacionadas con los flujos acuáticos diarios y los números promedio de días de desborde en enero y febrero.

La disponibilidad de salmón para las águilas, medida cada dos semanas a lo largo de 43 km del río, se presentó en exceso desde el 24 de noviembre de 1980 al 4 de enero de 1981, y en déficit el resto del invierno de este estudio. La disponibilidad de salmón a orillas del río continuó hasta mediados de enero; después de este tiempo, cuando el río bajaba su nivel, aparecían provisiones adicionales. Posteriormente el salmón de la especie *Oncorhynchus kisutch*, que desova en los tributarios, constituyó una mayor fuente de alimento.

Hemos marcado, en los sitios de desove, 214 peces vivos de la especie *O. keta*, después de la puesta de los huevos; y se estima, por los peces recobrados, que cerca del 13% estuvo disponible para las águilas. Las predicciones de la capacidad de mantenimiento del área estudiada, se basaron en el número de peces salmón en el río, en el índice de disponibilidad del 13% y en el requerimiento de alimento por día del Águila Cabeciblanca. Estas predicciones mostraron una estrecha correlación con el número de águilas cuyo mantenimiento dependía tanto de toda el área a lo largo del río Skagit como de una porción de ella especialmente estudiada.

Una muestra de águilas equipadas con radiotransmisores viajó al oeste, desde los ríos Skagit y Nooksack, hacia Puget Sound, donde estudios visuales mostraron incrementos en el número de águilas durante enero y febrero. Estos incrementos correspondieron con la bajada del nivel de los ríos.

[Traducción de Eudoxio Paredes-Ruiz]

Populations of birds of prey often appear to be at saturation-level densities in relation to food supplies

(Newton 1979). This relationship is most apparent among species with narrow food niches, such as the

Rough-legged Hawk (*Buteo lagopus*) and Gyrfalcon (*Falco rusticolus*), whose nesting populations in some areas reflect changes in food supply (Hagen 1969, Swartz et al. 1975, Platt 1976). Saturation of wintering habitat may be inferred from studies in which the densities of raptors correspond to yearly differences in prey abundance (Craighead and Craighead 1956, Cavé 1968, Smeenk 1974, Thiollay 1978). An actual determination, however, of whether a raptor population exists at carrying capacity requires that numbers of the birds be predicted from a measured amount of available food. Obtaining such data is usually difficult because of problems in 1) determining the available portion of food biomass (i.e., the number of vulnerable calories per unit time), 2) obtaining accurate counts of the raptors, and 3) assessing individual raptor food requirements.

Bald Eagles (*Haliaeetus leucocephalus*) are particularly appropriate subjects for studies of local carrying capacity during winter when they tend toward a diet of carrion (Southern 1963, McClelland 1973, Steenhof 1976, Griffin 1978). In the Pacific Northwest they are attracted to post-spawn salmon carcasses along rivers (Servheen 1975) and to concentrations of ducks and geese crippled or dead from disease and shooting (Keister 1981). Dead salmon lying in shallow water or on river banks are relatively easy to count, thereby allowing researchers to measure a substantial portion of the food actually available to eagles wintering along a river. Additionally, since Bald Eagles themselves are so conspicuous and are likely to be found close to the river, they are easily censused. Lastly, Stalmaster and Gesaman (1984) have developed an energetics model of the caloric requirements of captive Bald Eagles under simulated temperatures, rain, and wind, and have supplemented their estimates of caloric needs with field data on energy costs of wild eagles. They estimated that an average-sized 4.5-kg Bald Eagle wintering on the Nooksack River in western Washington requires about 491 kcal, or 486 g of salmon flesh, per day (Stalmaster 1983).

In this report we 1) estimate the biomass of salmon carrion which occurred during winter 1980-81 along the Skagit River drainage in northwestern Washington, 2) estimate the number of wintering Bald Eagles in attendance, and 3) examine variables which may have affected Bald Eagle carrying capacity during 7 years of censuses. Using tagged fish, we estimate the rate at which post-spawn salmon carrion became available as eagle food. We provide data on the movements of eagles from the Skagit River as food supplies di-

minished in late winter, and we report changes in eagle numbers in nearby areas that may have absorbed the Skagit River emigrants.

STUDY AREA

Bald Eagles wintering on the Skagit River are distributed along approximately 144 km of the river, from its mouth to Gorge Dam at Newhalem, but they concentrate between the towns of Rockport and Marblemount (Fig. 1). Two major tributaries, the Sauk and Cascade rivers, also attract eagles, as do local creeks and sloughs.

Physical and biotic features related to Bald Eagle occurrence on the Skagit River were described by Servheen (1975). The river runs through a glaciated valley, 1-5 km wide, which is characterized by the Western Hemlock (*Tsuga heterophylla*) life zone (Franklin and Dyrness 1973). In most areas the river banks have an abundance of trees suitable for Bald Eagle perching and the river contains numerous gravel bars where salmon carcasses tend to accumulate. River flows are regulated by three hydroelectric dams upstream of Newhalem.

Five species of salmon spawn in the Skagit drainage, but Chum Salmon (*Oncorhynchus keta*) are most important to Bald Eagles. Chum Salmon spawn from mid-November through December in the Skagit mainstem, side channels, and sloughs; carcasses accumulate along gravel bars during November and December and remain there as eagle food until eaten or removed by floods. Coho Salmon (*O. kisutch*) spawn throughout the winter mainly in tributaries, some of which are quite small. Coho Salmon are distributed more widely than chum, but are less commonly deposited on mainstem gravel bars. Pink salmon (*O. gorbuscha*) spawn abundantly in October in alternate years, but their carcasses are largely gone by the time eagles arrive in numbers.

We conducted telemetric and census work west of the crest of the Cascade Mountains in Washington and British Columbia, and from Seattle to about 80 km north of the city of Vancouver (Fig. 2). The region is a mosaic of agricultural lowlands and mountains covered by coniferous forests. Six major rivers (Squamish, Fraser, Nooksack, Skagit, Stillaguamish, and Snoqualmie) meander westward, often through multiple channels, and all support spawning salmon in winter months. The San Juan and Gulf archipelagos in nearby Puget Sound consist largely of gently rolling conifer-forested hills and cleared pastoral lands.

METHODS

Bald Eagle Censuses. Bald Eagles perched conspicuously in trees along the Skagit River and were readily counted from a slow-moving road vehicle and from a number of fixed vantage points. The census procedure and route were developed by Servheen (1975). Eagles were counted two or three times per week from late November through mid-March. The route followed the river from Newhalem downstream to the Sauk River confluence, a distance of 43 river km (Fig. 2). We also surveyed several off-river locations, including Illabot Slough, Harrison Slough and County Line Ponds, and a short section of the Cascade River near its mouth. For analysis, eagle census results were averaged for each of eight 2-wk periods.

To project the total number of eagles present in the study

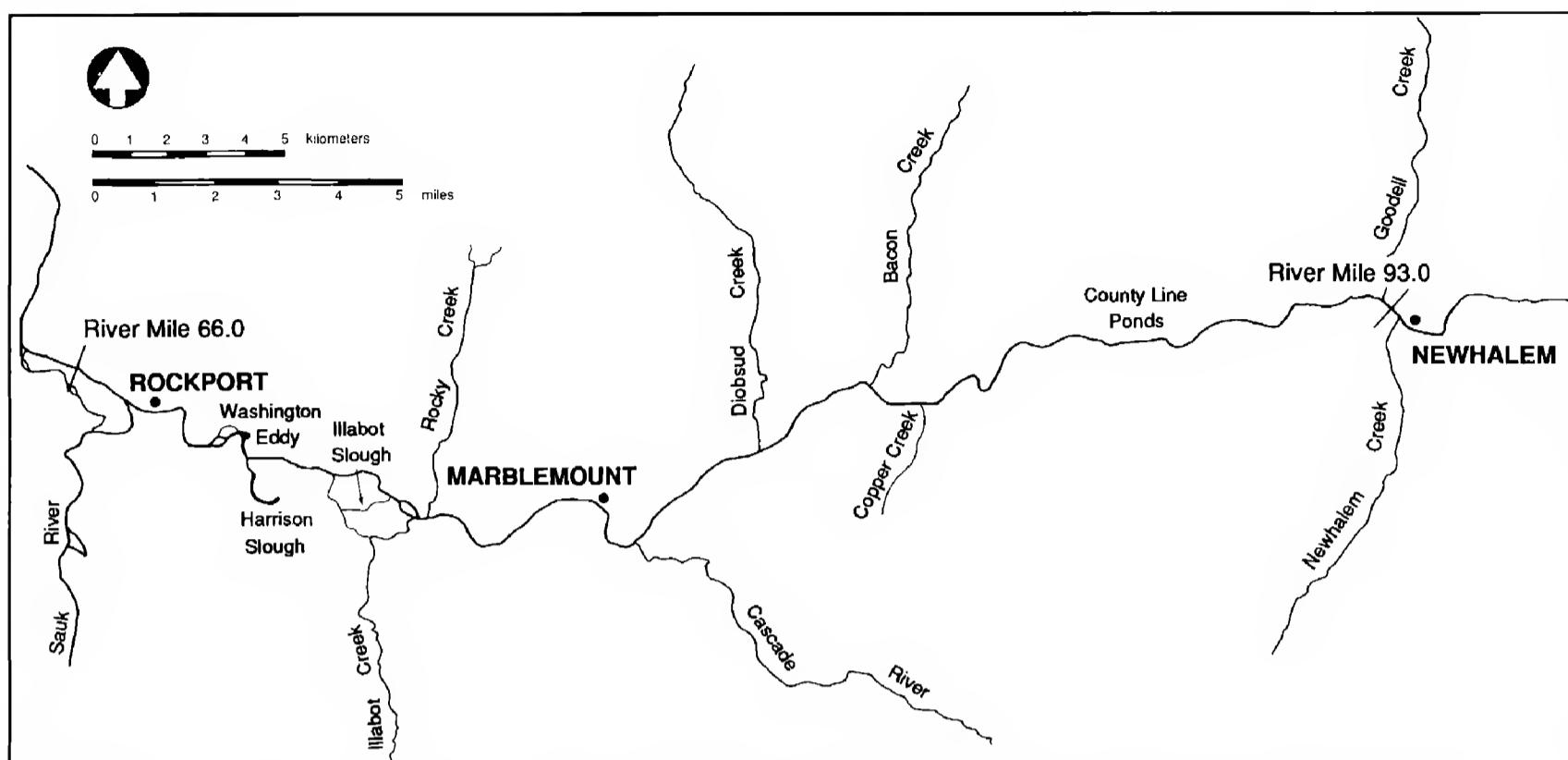


Figure 1. Upper Skagit River study area where Bald Eagles were counted and salmon carrion estimated.

area, we estimated the proportion of each standard half-mile (0.8 km) river segment (Williams et al. 1975) that was visible to the census-taker ($N = 54$ segments). We then divided the mean numbers of eagles seen in the segments by the resulting visibility coefficients to calculate the actual number of eagles present in each standard half-mile.

Because of more cryptic coloration, subadults perched in trees were more difficult to detect than adults. Following Hancock (1964), we examined adult to subadult ratios in samples of perched eagles, those flying, and those standing or feeding. During winter 1979–80 we recorded 244 subadults and 243 adults in our sample of flying eagles. We observed 138 subadults and 125 adults standing or feeding. However, the perched sample showed a ratio of 995 subadults to 1321 adults. We concluded that if perched subadults had been as readily seen as adults our overall sample of eagle observations would have been larger by about 10%, so we adjusted our estimates accordingly.

To evaluate differences in yearly numbers of wintering eagles we tabulated eagle census data from previous studies between Marblemount and the mouth of the Sauk River. These surveys were made in winters 1973–74 and 1974–75 by Servheen (1975), in 1976–77 and 1977–78 by Wiley (1977, 1978), and in 1978–79 by Skagen (1979). Additionally, we conducted censuses by boat every 2 wk during winter 1980–81 on the Skagit River from the Sauk River mouth to Sedro Woolley (67.2 km) and on the Sauk River from its mouth to Darrington (33.6 km).

Salmon Carcass Surveys. Throughout winter 1979–80 we conducted weekly counts at night of salmon carcasses at Washington Eddy, a gravel bar about 600 m long, between Rockport and Marblemount. The technique, first used by Servheen (1975), involved walking the length of a gravel bar along the edge of the water, and returning along the high water mark. All fish found were measured and classified

according to location, species, sex, proportion of flesh remaining, and whether accessible to eagles. We left all fish intact where found.

The following winter, using a shallow-draft jet-boat, we surveyed for salmon carcasses every 2 wk along the 43 km stretch of the Skagit River from Goodell Creek at Newhalem to the mouth of the Sauk River near Rockport (Fig. 1). We walked all exposed gravel bars and examined all backwaters, sloughs, eddies, high water marks, and river edges on foot or by boat and completed the counts in 2 d. We recorded data similar to those collected during the night counts (see above) and continued the surveys into late February when no edible fish parts were observed.

From a sample of 55 whole, post-spawn chum carcasses we determined average weights and measurements of both sexes of fish. Then, by subtracting the mean weight of salmon skeletons from which all edible portions had been consumed by eagles, we obtained average weights of edible flesh. We similarly estimated the weight of edible flesh on Coho Salmon using a sample of 10 post-spawn fish. For salmon carcasses of unknown sex, the average of male and female weights was used. From numbers of carcasses, and from the varying portions of flesh remaining, we calculated amounts of available fish biomass (in kcal) for each half-mile segment of river.

Salmon Disk-tagging. From 24 November to 19 December 1980, we captured 214 live, post-spawn Chum Salmon with drift nets in the upstream portion of the study area between Copper Creek and Goodell Creek. The distribution of capture sites fairly represented the location of major Chum Salmon spawning activity in this section. In all, we tagged 173 fish in the mainstem and 41 in a side-channel. After capture we immediately placed each fish in a water-filled tank to await processing. All were tagged, while in a water trough, with numbered blue plastic disks (Peterson style, with single green flags) attached by nickel pins just below the

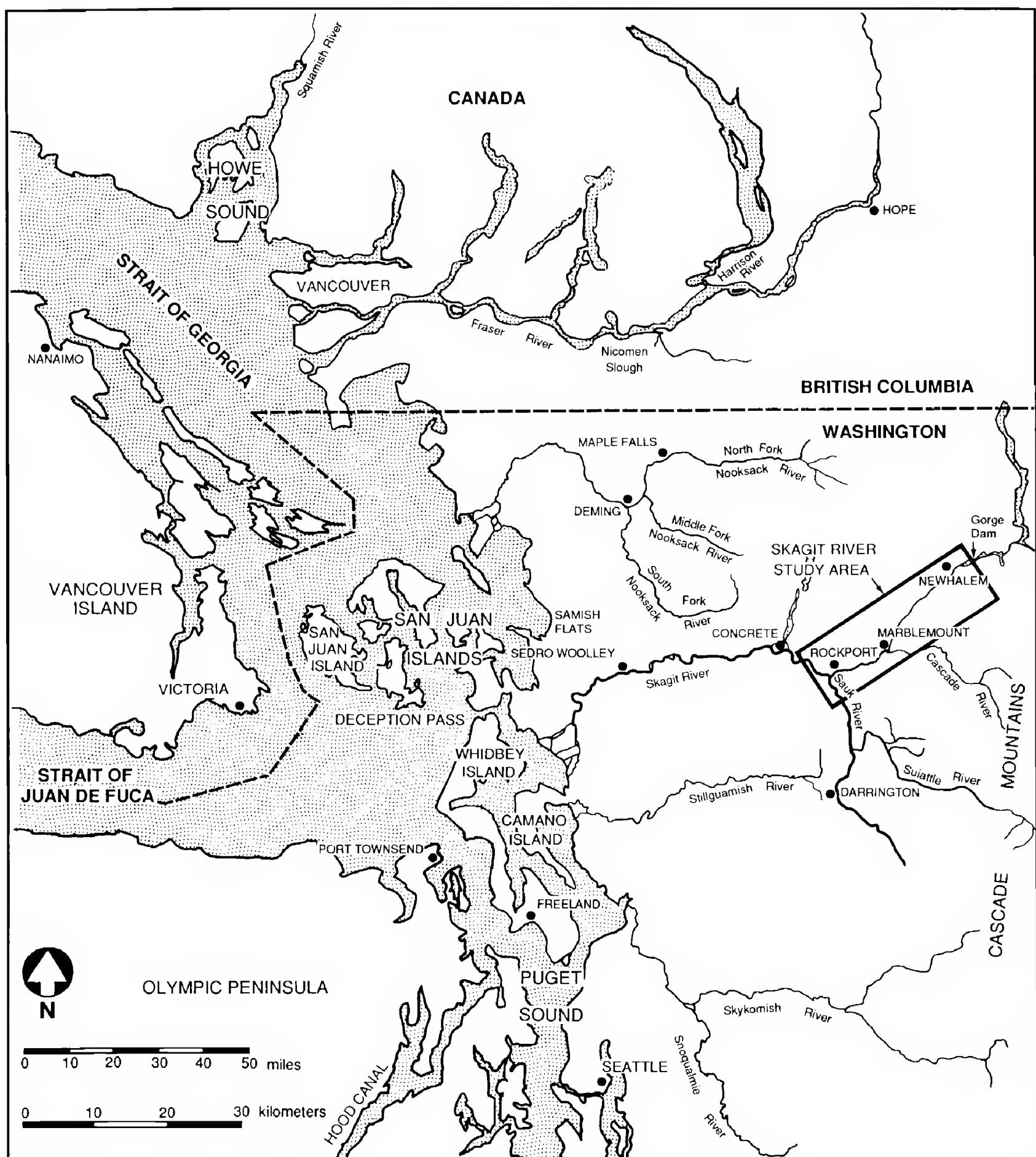


Figure 2. Study region to which radio-tagged Bald Eagles traveled from the Skagit and Nooksack rivers.

dorsal fin (Nielsen and Johnson 1985). Each fish was scored as to sex, length and state of vigor, and was released at the capture site within a few minutes of netting. We judged 188 fish to be in good or excellent condition, 24 to have little vigor and 2 to be very weak. We searched for tagged fish during

our routine carcass surveys and conducted two extra searches solely for tagged fish during December. All fish counted in the surveys were examined for tags or evidence of tag placement.

Radio Telemetry. During January and February of 1980

Table 1. Factors that may influence the numbers of Bald Eagles wintering on the Skagit River from Marblemount to the mouth of the Sauk River. Census data were obtained from the following sources: 1973-75 from Servheen (1975), 1976-78 from Wiley (1977, 1978), 1978-79 from Skagen (1979), and 1979-81 (this study).

WINTER	SKAGIT RIVER EAGLE ABUNDANCE INDEX				MEAN DAILY FLOW ^c		MEAN NUMBER	HIGHEST DAILY FLOW ^c	PRECIPITATION (inches) ^d	AIR TEMPERATURE ^d
	WINTER	SKAGIT	NOOK-SACK	CHUM SALMON ^b	FRASER	SQUAMISH	DEC.- JAN.	OF FLOOD DAYS ^{c,d}	DEC.- JAN.	DEC. + JAN.
1973-74	4.0	31	20	453	235	19-24	7	31-73	31	2.9
1974-75	6.5	57	15	565	142	16-17	2	43-32	27	3.3
1975-76	No data	20	10	235	55	35-20	12	108-32	30	3.3
1976-77	6.2	85	7	589	114	12-15	2	23-46	11	3.4
1977-78	6.0	32	16	539	120	26-15	9	58-20	19	3.1
1978-79	13.9	115	9	487	114	11-10	0	14-15	12	0.2
1979-80	5.0	16	23	328	26	28-16	8	114-22	23	2.2
1980-81	4.6	21	25	375	222	30-15	10	120-38	15	4.7
Mean values	6.6	59	16	476	139	20-16	5.4	58-35	19.7	2.8

^a Eagle abundance index values were computed by summing mean numbers of eagles observed per day per 2-wk periods 2-7 (see Table 2). The results were divided by 1000.

^b Salmon escapement values (divided by 1000) obtained from the Departments of Fisheries, Washington and British Columbia.

^c Flow (cubic feet per second divided by 1000) records from U.S. Geological Survey (measured at Concrete, Washington).

^d Flood days were arbitrarily identified as those when average flows exceeded 30 000 cubic feet per second; precipitation and temperature figures were obtained from U.S. Office of Climatology (measured at Concrete, Washington).

and 1981, we captured 25 Bald Eagles with padded and weakened leg-hold traps and fit each eagle with a radio transmitter. We caught 10 eagles on the Skagit River and 7 on the Nooksack River in 1980, and 6 on the Skagit River and 2 on the Nooksack River in 1981. Radio transmitters (Telomics, Inc., Mesa, AZ; 2-stage), weighing 27-41 grams and containing batteries with a 5-month life, were tied and glued to the dorsal bases of the central 2 rectrices (Young 1983). Each eagle was released at the place of capture.

We tracked eagles with road vehicles and fixed-wing airplanes using a Telomics TR-2 receiver coupled with a TS-1 programmable scanner. Airplane telemetry surveys included the part of western Washington and British Columbia lying west of the Cascade crest and the town of Hope, British Columbia, north of Olympia and Gray's Harbor in south-western Washington, and south of Nanaimo on Vancouver Island. Our radio-tracking flights occasionally covered the entire area but concentrated on Puget Sound, Hood Canal, the western Cascade slope north of Seattle, the Skagit, Nooksack, and Fraser river valleys, the San Juan Islands, Howe Sound and the lower Squamish River, and the eastern side of Vancouver Island.

Regional Censuses. We censused Bald Eagles at least once every 2 wk from 24 November 1980 through 14 March 1981 in the following six areas believed to be potential destinations of eagles emigrating from the Skagit River: 1) Samish Flats. From near Blanchard on Samish Bay to the southern end of Padilla Bay, including Hat Island and March Point Peninsula; censused by road vehicle. 2) Deception Pass. Deception Island and mainland shores as viewed from Pass

Island and Deception Pass State Park Beach; primarily a foot census. 3) San Juan Island. From Friday Harbor Airport southeast to Cattle Point and back on American Camp Road, by road vehicle. 4) Nooksack River. Between Maple Falls and Deming including about 8 km of the Middle Fork and 21 km of the North Fork; by road vehicle. 5) Fraser River (British Columbia). Three separate locations: the mouth of the Harrison River, Nicomen Slough, and the Fraser River near Hope; by road vehicle and on foot. 6) Squamish River (British Columbia). From Westwold Gate downstream 30 km to the estuary and including a 5 km segment of the Cheakamus River, 2 km of the Mamquam River, and Judd Slough; by road vehicle and on foot. Each census team consisted of a vehicle operator (where appropriate) and an observer who searched, with binoculars and a 20-power spotting scope, for eagles in trees, on gravel bars, driftwood, riverbanks, and in the air. Two-week periods were standardized for comparison between units, and if more than one census was performed in a 2-wk period a mean number of eagles was calculated.

RESULTS AND DISCUSSION

Differences in Yearly Eagle Abundance. Bald Eagles appear in numbers on the Skagit River in November, peak in January in most years, and leave by mid-March. Table 1 shows gross differences in numbers of Bald Eagles counted along the Skagit River between Marblemount and the Sauk River during

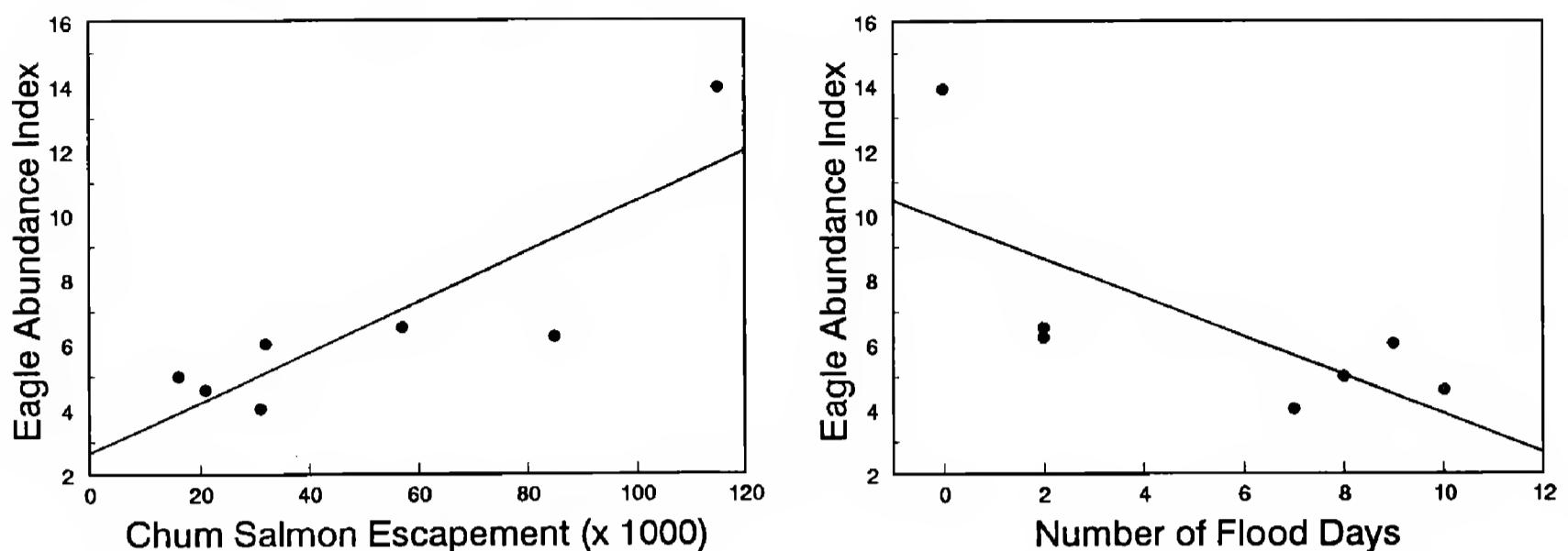


Figure 3. Relationship of Bald Eagle numbers on the Skagit River to 1) the estimated number (escapement) of Chum Salmon ascending the river to spawn, and 2) the number of flood days recorded.

seven winters of censusing. Eagle numbers were significantly correlated with Chum Salmon escapement (the number returning to spawn) to the Skagit River (Spearman rank correlation $\rho = 0.821$, $P < 0.05$; Wilkinson 1985), and negatively correlated with daily flow rates and numbers of flood days averaged for January and February (Spearman $\rho = 0.857$, $P < 0.05$, in both cases; Fig. 3).

During winter 1978–79, characterized by low temperatures and low rainfall, Skagen (1979) observed more than twice the number of eagles on the Skagit River than in other years. Numbers of spawning Chum Salmon that year were estimated by the Washington Department of Fisheries to be the highest on record. River flows were low, and no daily average discharge of over 30 000 cubic feet per second (flooding) was recorded at the gauging station at Concrete, Washington, during December and January. In contrast, flooding occurred on the Skagit River on an average of 6.3 d in this same two-month period during each of the other six years. The low flows recorded during 1978–79 probably caused a higher than normal rate of salmon carcass deposition on gravel bars (M. Aguero pers. comm.) and no floods occurred to wash the carrion away.

Servheen (1975) counted very large numbers of Chum Salmon carcasses on Washington Eddy gravel bar in winter 1974–75, when the number of high-water days and the mean December flow were both below average. During the last week in December he found 700 whole or partially consumed fish. By comparison, in the corresponding week during winters

1979–80 and 1980–81 we found only one and three fish, respectively, on the Washington Eddy bar.

Numbers of eagles on the Skagit River also may be influenced by availability of salmon carcasses on other rivers in the region. During winter 1978–79, when Skagen (1979) witnessed unusually high eagle numbers on the Skagit River, the escapement of Chum Salmon to the Nooksack River (Fig. 1) was 9000, or 56% of the mean (Table 1). This was a significant reduction from the previous high of 20 000 spawners in 1973–74. In the Fraser River in nearby British Columbia an average number of chum spawned in 1978–79, but the Squamish River (Howe Sound, BC), which is known to attract large numbers of eagles, had a slightly below average chum escapement. Attraction of eagles to other rivers also may explain why the large numbers of salmon carcasses recorded by Servheen (1975) on the Skagit River in 1974–75 did not generate an attendance of eagles comparable to that in 1978–79 (Table 1).

Relatively low numbers of eagles visited the Skagit River during winters 1979–80 and 1980–81. In both years Chum Salmon escapements there were far below average, while river flows were higher than in other years, both in mean daily flows and in highest water levels (Table 1). Chum Salmon escapements to the nearby Nooksack River in both years were the highest recorded for that river. Note that there were more eagles and fewer fish on the Skagit River in 1979–80 than in 1980–81. Chum Salmon escapement to the Squamish River (180 km to the north, which normally supports more eagles than the Skagit River) was ex-

Table 2. Eagles and salmon carcasses in the Skagit River study area during winter 1980–81. Eagle numbers were projected on the basis of visibility of each one-half-mile segment surveyed plus a weighting factor for perched subadults (see Methods). Eagle requirements of 486 g per day are from Stalmaster (1983).

TWO-WEEK PERIOD	MEAN NO. EAGLES PER DAY	EDIBLE CHUM (kg)	EAGLE REQUIRE- MENT (kg)	DAYS EAGLES		FOOD SURPLUS (kg)	NO. CHUM (OR COHO) NEEDED
				SUPPORT- ED BY FOOD SURVEYED	EXPECTED 2-WEEK CONSUMP- TION (kg)		
1 24 November–7 December	40.9	1217.0	19.9	61.2	278.3	+939	0
2 8 December–21 December	109.6	1264.2	53.3	23.7	745.7	+518	0
3 22 December–4 January	94.7	733.1	46.0	15.9	644.3	+89	0
4 5 January–18 January	121.5	452.0	59.0	7.6	826.7	–375	102 (217)
5 19 January–1 February	110.6	227.0	53.7	4.2	752.5	–525	142 (303)
6 2 February–15 February	95.0	89.7	46.2	1.9	646.4	–557	151 (322)
7 16 February–28 February	57.8	0	28.1	0	393.3	–393	0 (227)
8 1 March–14 March	16.0	0	7.8	0	108.9	–109	0 (63)

tremely low in 1979–80 (19% of the mean), and it is quite possible that some of the eagles displaced thereby such a food shortage might have gone to the Skagit and Nooksack rivers.

The lowest numbers of eagles on the Skagit River during the 7-year period was in winter 1973–74, when the chum escapement was estimated to be about one-half the average. Other conditions probably also contributed to the relative sparsity of eagles there: a flood occurred on the Skagit River in January, and the Nooksack and Squamish rivers showed above average Chum Salmon escapement.

Available Salmon Biomass. Based on weights of post-spawn salmon carcasses, we estimated that the average Chum Salmon carcass from the Skagit River weighed 4.78 kg, of which 3.69 kg might have been used by eagles. Each Coho Salmon produced, on average, about 1.73 kg of edible flesh.

Table 2 shows the relationship of projected Bald Eagle numbers along the 43 km long study area to the measured amount of salmon flesh available during winter 1980–81. From 24 November to 4 January the amount of food we found along the river was in surplus of that required by the eagles present. However, a deficit of available salmon compared to eagle requirements occurred after mid-January. The deficit continued to mount through 15 February and then declined as eagle numbers steadily diminished.

Persistence of Bald Eagles during the period in which we observed the biomass deficit implied either that recruitment of carcasses continued or that eagles were

obtaining food from other sources. For example, during the fifth 2-wk period, when the estimated amount of available food should have sustained the eagles present in the study area for only 4 d, there was still enough fish flesh available 2 wk later to feed the eagles present for 2 d.

During our twice-monthly carcass counts we found “new” fish on the gravel bars as older ones were eaten or had otherwise disappeared. Until about 9 January 1981 these were primarily recently spawned Chum Salmon, but after 21 January there was no evidence of such recruitment. However, there was a gradual reduction in river flow from early January until mid-February. As the water receded, carcasses caught in low vegetation and in backwater pools were exposed or became available to eagles in shallow water.

To test attrition of the food value of carcasses, we collected 17 muscle tissue samples from dead Chum Salmon for caloric measurement. Laucks Testing Laboratories, Inc. (Seattle, WA) detected no variation in protein, fat, and caloric contents between tissue samples collected on 22 December 1980, on 21 January 1981 and on 3 February 1981 (ranges = 13.8–15.2% protein, 0.1–0.3% fat and 0.60–0.67 kcal/g).

Coho Salmon spawning in tributaries served as a principal food for eagles after mid-January. Table 2 shows the numbers of Coho Salmon carcasses (in parentheses) required to make up the food deficit computed for each 2-wk period. Eagles that could not find food on the main gravel bars in the study area could have been supported by 1132 Coho Salmon carcasses.

This represents about 13% of the estimated natural (non-hatchery) Coho Salmon escapement to the study area (Washington Department of Fisheries, 1977 Coho Salmon distribution estimate).

Many of the Coho Salmon carcasses accessible along tributaries were probably swept into deeper water during flooding. However, a series of ponds ("County Line Ponds," Fig. 1) provided Coho Salmon carrion for Bald Eagles through February and early March 1980, despite high water in the nearby Skagit River. These ponds, created as gravel pits during a dam construction project, were inundated by ground water percolation and were connected with the Skagit River mainstem via two small outflows. Were such habitat more abundant along the river, larger numbers of eagles could have been sustained.

Other potential food sources in the study area included mammal and bird carrion, live rabbits and live waterfowl. During our field work in both years we found carcasses or remains of several ducks, four deer, a rabbit, a gull, a raccoon and a beaver. Some of these had been eaten by eagles, however, it was our impression that densities of these potential foods in the study area were quite low, hence they were probably not very important to eagles.

Territoriality by some adult eagles along the river may have accounted for short-term preservation of chum carcasses. Certain individuals guarded carcasses against other eagles and we speculate that this extended the utilization of a carcass by an individual eagle over several days. The consequence of such behavior, if it occurred widely in the wintering population, might partially account for the apparent availability of carcasses through February.

Local Carrying Capacity for Bald Eagles. Of the 214 live post-spawn Chum Salmon we tagged with numbered plastic disks in the upstream portion of the study area, we found 29 as carcasses during gravel bar surveys. An additional tagged fish was taken alive in a net by fishermen 131 km downstream of the release site. The 29 carcasses represent 13.5% of the total number tagged. They drifted a mean distance of 7.7 km (range 0–37.8 km) from points of tagging or last recapture, and had an average recovery interval of 13.6 d (range 1–37 d). We detected no significant difference between recovery rates of salmon tagged in the mainstem and in the side-channel. Of 173 Chum Salmon tagged on the mainstem, 18 (10.4%) were found on the mainstem when dead and available to eagles.

Of the 29 tagged salmon recovered, 10 had been fed on by bears near the area of tagging. All remaining

19 recoveries were either on shore or exposed in shallow water and all were available to eagles. Of these, 2 had been completely devoured by eagles (except for head and bones), 7 were partially eaten by eagles and 10 were intact. Each tagged carcass was apparently available only for a short time since we never located a tagged carcass on a subsequent survey.

We initially assumed that salmon were deposited on gravel bars by simply drifting there after death. However, during our gravel bar counts, particularly those at night, we observed live salmon actively beaching themselves by "nosing" into shallow water, and they did so even after we repositioned them in deeper water. This beaching may be an important mechanism by which salmon become available to eagles.

The data from the Chum Salmon disktagging allowed us to estimate the carrying capacity of the Skagit River for Bald Eagles. Based on our regular eagle censuses in the Skagit River study area, the Sauk River, and the lower Skagit River from the Sauk River confluence to Sedro Woolley, we estimate that 22 743 eagle-days occurred in the entire Skagit drainage during winter 1980–81 (see Methods section). Our component estimates are as follows: Skagit River (Sauk River mouth to Gorge Dam) 9288, Lower Skagit River 6744, Sauk River (mouth to Darrington) 3705, Sauk River (upstream of Darrington) 926, Suiattle River 1080 and all other tributaries = 1000 eagle days.

The predicted Chum Salmon escapement (Washington Department of Fisheries estimate) to the Skagit drainage for winter 1980–81 was 21 350 fish. If 13% became available to eagles, as suggested by our salmon tag recoveries, and if Stalmaster's estimate of 486 g required by each eagle per day is correct (Stalmaster 1983), Chum Salmon provided potential food for 21 073 eagle-days. This figure falls close to the 22 743 eagle-days we calculate having actually occurred in the Skagit system.

In an intensively studied area, there was also agreement between the numbers of eagles and the numbers of spawners. Based on a Peterson index, we estimated that 3400 Chum Salmon spawned in the 14 km of the Skagit River between Copper Creek and Goodell Creek, where we captured salmon for disk tagging. If about 4% became available to eagles within this area, as tag recoveries suggest (side-channel carcasses eaten by bears excluded), then about 136 chum carcasses occurred as potential eagle food. These contained about 502 kg of edible flesh, which could support, if eagles were the only beneficiaries, a total of 1033 eagles for 1 d. From our eagle censuses we projected that 1096 eagle-days

actually occurred in this stretch of river during the winter.

The relationship between food availability and eagle occurrence is more complex than suggested by these close fits. Our carcass surveys demonstrated early surpluses and late-winter deficits of Chum Salmon. While it is conceivable that, during the early period, most or all of the excess Chum Salmon carrion (as noted in the surveys) persisted on the gravel bars until eaten by eagles, the deficits apparent by mid-January implied the existence of additional food, namely Coho Salmon off the mainstem.

Bald Eagle Movements. Our findings indicate that, at least in years of moderate to low salmon carcass availability, Bald Eagle numbers on the Skagit River after mid-January are rather closely defined by food availability. In flood years or those of low salmon escapement, eagles are forced, sometimes suddenly, to abandon salmon carrion for other types of food. For yearling eagles, the loss of salmon as a food option may require the hasty development of new foraging skills. To explore these considerations, we tried to determine destinations of eagles departing the Skagit and Nooksack rivers and how they might obtain food.

Five of the 25 telemetered eagles remained for at least one month along the river where they were captured. Those in the Skagit drainage ($N = 3$) responded to local depletions of Chum Salmon carrion by relocating to stretches of river where carcasses were more abundant or to tributaries or ponds where spawned-out Coho Salmon were accessible. In 1979–80, when Coho Salmon evidently were important to eagles, four of the five radio-tagged birds remaining along the upper Skagit River held tenaciously to Coho Salmon concentrations.

As food diminished, telemetered eagles left the upper Skagit and Nooksack rivers (Table 3). Seven radio-tagged birds flew to river areas other than where they were captured. Presumably attracted to salmon carcasses, they went to the lower Skagit, the Sauk, the Snoqualmie, and the Fraser rivers (Table 3). Two eagles tagged on the Skagit River (No. 7 and 9) moved upstream toward Newhalem, and then presumably departed eastward. Several other telemetered birds may also have gone eastward since we failed to detect them to the west, northwest or southwest. At least seven radio-tagged eagles eventually flew westward to Puget Sound or the Strait of Georgia. We detected them in the San Juan Islands, Deception Pass, on coastal flats and at estuaries. At least two of these eagles may have summered at Puget Sound: one adult was still in the

Puget Sound area on 13 April 1980, after which it lost its transmitter. Another adult (No. 22) remained in Puget Sound environs through at least 7 June 1981, when radio-tracking flights were terminated. R. Knight (pers. comm.) believed the bird to be associated with a nest on Protection Island near Port Townsend on 9 April 1981, but by 17 April it frequented the vicinity of Freeland on Whidbey Island, on 12 May Lofall on Hood Canal, and by early June Freeland again.

Several records of long-range movement were obtained during this study. Two subadults, tagged in early February, were detected at Knight Inlet, British Columbia, on 19 April 1981. One eagle was in southeast Alaska on 26 February 1981 (J. Hodges pers. comm.). Movements to the south included an adult south of Olympia, Washington, on 6 March 1981, and another adult on 13 February 1981 at Lower Klamath Lake in northern California (Keister 1981). This bird returned to the Skagit River by 26 February but was not detected thereafter. Servheen and English (1979) present a discussion of migration routes to and from the Skagit drainage.

Regional Eagle Censuses. As Bald Eagle numbers decreased along six rivers from January to February, wintering populations generally increased during the same period at three census locations near Puget Sound (Table 4). Both census data and the telemetry data are in agreement that some of the eagles displaced from rivers by declining salmon carrion were attracted to Puget Sound.

Foraging opportunities were diverse in the bays, estuaries, beaches, and coastal flats of Puget Sound and the Strait of Georgia. At Samish Flats, eagles fed mainly on waterfowl. C.M. Anderson (in lit.) recorded 53 birds (including 47 waterfowl) in a sample of 62 eagle prey. C.M. Anderson also observed eight attempts by Bald Eagles to capture live ducks; two of these were successful. L. Brewer (pers. comm.) saw eagles take flying gulls and wounded geese in shallow water. Eagles have also been observed foraging in the littoral zone of Puget Sound (C. LaRiviere in lit., see also Vermeer and Morgan 1989); we saw a radio-tagged subadult take fish stranded in a tidal pool. Prey records from San Juan Island include fishes, Old World rabbits (*Oryctolagus cuniculus*), and seabirds (Retfalvi 1965, 1970, Knight et al. 1990).

Some of the straits and channels in Puget Sound attracted Bald Eagles. At Deception Pass on 3 March 1981 we watched a number of eagles perched in conifers overlooking the channel. We observed no apparent foraging behavior for 6 hr, but at the tidal

Table 3. Movements of radio-tagged eagles by 2-week period. Birds 1-10 were tagged on the Skagit River (Census Unit 1) in January and February 1980; birds 11-17 on the Nooksack River (Unit 7) in February 1980; birds 18-22 and 25 on the Skagit River in January and February 1981; and birds 23-24 on the Nooksack River in February 1981. Locations outside of the study region (see Figure 1) are marked with an asterisk.

ESTI- MATED NO.	EAGLE No.	AGE (years)	Two-Week Period				LAST LOCATION	DATE
			22 DEC.- 4 JAN.	5 JAN.- 18 JAN.	19 JAN.- 1 FEB.	2 FEB.- 15 FEB.		
1	2	2	Skagit R.	—	Puget Sound	Puget Sound	Fraser R.	Mar. 28
2	2	Skagit R.	—	—	Snoqualmie R.*	Puget Sound	Puget Sound	Apr. 2
3	1	—	Skagit R.	Skagit R.	Skagit R.	Skagit R.	Nooksack R.	Mar. 20
4	1	—	Skagit R.	Puget Sound	Puget Sound	Puget Sound	Strait of Georgia*	Apr. 2
5	5+	—	—	Skagit R.	Skagit R.	Skagit R.	Fraser R.	Feb. 25
6	5	—	—	Skagit R.	Skagit R.	Skagit R.	Sauk River	Mar. 1
7	3	—	—	Skagit R.	Skagit R.	Skagit R.	Skagit R.	Mar. 14
8	5	—	—	—	Skagit R.	Skagit R.	Skagit R.	Feb. 13
9	3	—	—	—	Skagit R.	Skagit R.	Skagit R.	Feb. 10
10	2	—	—	—	Skagit R.	Skagit R.	Skagit R.	Feb. 22
11	5+	—	—	—	Nooksack R.	Nooksack R.	Puget Sound	Apr. 13
12	1-2	—	—	—	Nooksack R.	Nooksack R.	Knight Inlet, B.C.*	Apr. 25
13	3	—	—	—	Nooksack R.	Nooksack R.	Fraser R.	Feb. 29
14	3	—	—	—	Nooksack R.	Nooksack R.	Nooksack R.	Mar. 5
15	3	—	—	—	Nooksack R.	Nooksack R.	Fraser R.	Mar. 8
16	2	—	—	—	Nooksack R.	Nooksack R.	Nooksack R.	Feb. 19
17	3	—	—	—	Nooksack R.	Nooksack R.	Knight Inlet, B.C.*	Apr. 25
18	5+	—	Skagit R.	—	N. California*	Skagit R.	Skagit R.	Feb. 26
19	5+	—	Skagit R.	—	—	—	SW Wash.*	Mar. 6
20	5+	—	Skagit R.	Mar. 13				
21	1-2	—	Skagit R.	—	—	—	Skagit R.	Jan. 18
22	5+	—	—	—	—	—	—	—
23	1-2	—	—	—	—	—	Puget Sound	Jun. 7
24	3	—	—	—	—	Fraser R.	SE Alaska*	Feb. 26
25	3	—	—	—	—	Nooksack R.	Nooksack R.	Feb. 22
					—	—	Skagit R.	Feb. 28

change we recorded at least 9 successful foraging attempts in 1 hr and saw up to 16 eagles soaring in a group over the channel. In one instance eight eagles vied for possession of one fish. Typically, eagles took 15–25 cm long fishes from the surface of the water. The prey were most likely Pacific Sandlance (*Ammodytes hexapterus*), which are known to stem the tidal currents of channels in large schools. In addition, spawning runs of Pacific Herring (*Clupea harengus*) occur in February and March in the Deception Pass area (Simenstad et al. 1979). During the tidal ebb, when we observed the foraging eagles, the waters of Deception Pass move with great force and velocity. Resultant upwelling currents may make certain fish vulnerable or perhaps underwater predators such as salmon or harbor seals become sufficiently active at these times to force small fish to the surface. Eagles also frequent Active Pass in the Gulf Islands (R.W. Campbell pers. comm.), and Retfalvi (1965) observed that nesting eagles at San Juan Island prefer to forage in narrow channels rather than open water.

Summary and Management Implications. Data from the Skagit River support the hypothesis that the overall number of eagles present during the winter is a function of the availability of salmon carcasses. While the latter depends mainly on the number of salmon ascending the river to spawn, several additional factors influence carcass availability to eagles. Low river flows are most conducive to carcass deposition on gravel bars, while high water tends to remove carcasses or place them out of sight in vegetation. Low flows are encouraged by low precipitation, restrictive dam regulation and low air temperatures. The latter produces and retains snow at higher elevations, while higher temperatures, especially with heavy rains, cause snowmelt and flooding.

During our study, Bald Eagles were below carrying capacity during November and December. A reason for this is that Chum Salmon spawn earlier in southeastern Alaska and northern British Columbia than in the Puget Sound region, and these areas may retain eagles in the early part of the winter (Waste 1982). In general, when salmon carcasses are available in abundance on other rivers in the Northwest, lower numbers of eagles might be expected to concentrate on the Skagit River.

Spawning areas such as shallow sloughs, because of their physiography, are more likely than other habitats to accumulate accessible fish carcasses. Sloughs, gravel bars, backwaters and other shallow habitats favoring carcass deposition are widely distributed, and may be

Table 4. Results of Bald Eagle censuses in the Pacific Northwest during winter 1980–81. Asterisks indicate only one survey was performed within the month, all other figures are averages of two or more surveys.

	MEAN NO. OF EAGLES PER SURVEY				% CHANGE JANUARY TO FEBRUARY
	DECEMBER	JANUARY	FEBRUARY	FEBRUARY	
Rivers					
Upper Skagit	61	81	49	—	—39
Lower Skagit	41	80	31	—	—61
Sauk	32	*44	19	—	—57
Nooksack	84	178	67	—	—62
Fraser	230	373	117	—	—69
Squamish	310	955	220	—	—79
Puget Sound					
Deception Pass	2	7	25	—	+257
Samish Flats	15	25	27	—	+8
San Juan Island:					
Ground survey	25	26	41	—	+64
Air survey	—	*110	*138	—	+25

differentially affected under varying hydrologic conditions. A wide distribution of spawners may therefore favor high overall eagle numbers, and is dependent on spawning habitat management, sympathetic programs of dam operation and possibly high genetic variability of salmon.

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DEMOGRAPHY OF WINTERING ROUGH-LEGGED HAWKS IN NEW JERSEY

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ABSTRACT.—We compiled Christmas Bird Count data on Rough-legged Hawk (*Buteo lagopus*) numbers from New Jersey for 1954 to 1989. Analysis state-wide revealed patterns not formerly observed on the continental or local scales. Major concentrations of wintering Rough-legged Hawks were along coastal areas in southern New Jersey. This abundance pattern was positively correlated with county wetland percentage and number of frost-free days. Considering previous studies which have found this species to avoid snow cover, it appears that these coastal marshes provide the proper habitat-climate gradient most favored by Rough-legged Hawks wintering in New Jersey. Throughout the period examined, no overall change in population size was observed.

Demografía de la aguililla de la especie *Buteo lagopus* en el invierno, en Nueva Jersey

EXTRACTO.—Del conteo de aves que se realiza en navidad, hemos analizado datos referentes a la aguililla de la especie *Buteo lagopus*, en Nueva Jersey, desde 1954 hasta 1989. Estos análisis, que incluyen data de todo el estado, revelaron tendencias demográficas que no han sido observadas anteriormente a escala continental o local.

Las mayores concentraciones del *B. lagopus*, en invierno, estuvieron a lo largo de las áreas costeras del sur de Nueva Jersey. Esta norma de abundancia ha sido positivamente correlacionada con el porcentaje de tierras húmedas en el estado, y con el número de días sin heladas. Considerando estudios previos, que han encontrado esta especie evadiendo zonas cubiertas de nieve, parece ser que estos esteros costeros proveen la gradiente de hábitat-clima apropiado que es mayormente preferido por el *B. lagopus* en invierno, en Nueva Jersey. A través del período examinado no se observaron cambios mayores en el tamaño poblacional.

[Traducción de Eudoxio Paredes-Ruiz]

In North America, the Rough-legged Hawk (*Buteo lagopus*) is a tundra-nesting raptor in the high arctic of Canada and Alaska (Cade 1955, Poole and Bromley 1988) but it winters throughout much of the United States (Root 1988). Thus, conservation and management of this large *Buteo* depend upon factors affecting its habitats in both Canada and the United States.

Previous investigations on the winter ecology of the Rough-legged Hawk have focused primarily on obtaining local and regional abundance estimates. Gruber and Golden (1960) analyzed Christmas Bird Count data in Illinois from 1905 to 1955 to examine trends in raptor populations. Density estimates based

on road transect surveys have been reported by Schnell (1967), Call (1975), Phelan and Robertson (1978), Baker and Brooks (1981) and Andersen et al. (1985). Some studies correlated abundance with habitat preference (St. John 1980, Fischer et al. 1984, Bildstein 1978).

Continent-wide winter distributions of Rough-legged Hawks based on Christmas Bird Count data were described by Bock and Lepthien (1976) and Root (1988). Wintering concentrations of Rough-legged Hawks in the Great Plains and intermountain area were correlated primarily with climatic conditions and presence of protected habitats such as wildlife refuge areas (Root 1988). However, while continent-wide studies are useful in documenting broad distribution patterns, such studies do not address the relationships between Rough-legged Hawk abundance and macrohabitat, a fundamental component of population management.

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In this investigation, we used a state-wide analysis to explore relationships between wintering Rough-legged Hawks and macrohabitat preferences based on numbers recorded on Christmas Bird Counts in New Jersey. We describe the results of this analysis and evaluate their potential use for conservation.

METHODS

New Jersey was selected for this analysis because 1) it has one of the densest concentrations of Christmas Bird Count (CBC) stations of any state, 2) the distribution of stations is fairly uniform throughout the state producing a representative geographic sampling, 3) the state contains a large diversity of macrohabitats (Fig. 1A) including: coastal marshes, coastal plain (including the pinelands), piedmont, highlands, and ridge and valley, 4) the authors have spent over a decade observing Rough-legged Hawks in various New Jersey habitats.

Data were tabulated from annual CBC counts published in *American Birds* and *Audubon Field Notes* from 1954 to 1989. To compare trends in distribution, count data for each CBC station were standardized as numbers per party-hours to account for different measures of field effort between years (Raynor 1975). A map of New Jersey was used to plot the approximate center of CBC location (by coordinates) and symbols of different sizes were used to illustrate size classes of population density of Rough-legged Hawks (mean number per 1000 party-hours from 1965-84). The distribution map was then overlayed with maps of county wetland percentages (from Tiner 1985), physiographic provinces, frost-free days, and human population density per county (Robichaud and Buell 1973) to evaluate demographic patterns in hawk abundance. Linear regression analysis (Zar 1974) was used to determine the strength of correlations between demographic variables and the mean winter abundance of Rough-legged Hawks at 25 CBC stations. The significance of slopes was determined by ANOVA (Zar 1974).

We also totaled counts for all stations each year to illustrate the magnitude of yearly fluctuations in Rough-legged Hawk populations within the state. To do this, we calculated 1) the log of the total number of hawks per total number of party-hours per year and 2) the yearly proportion of CBCs in which this species was recorded. If a Rough-legged Hawk was reported as present in the count area during the count week, but not seen on the count, we recorded one individual unless a larger number was given.

RESULTS AND DISCUSSION

Distribution. The CBC data suggest that wintering Rough-legged Hawks are widely distributed throughout New Jersey (Fig. 1A). The distribution map suggests a marked preference of these wintering hawks for the southern New Jersey coastal areas. Conversely, the overall distribution pattern shows a general avoidance of highland and inland areas. Although Rough-legged Hawks were recorded at almost all New Jersey CBC stations that were active

for 10 or more years, they were rarely observed at several inland count stations (including Trenton, Northwest Gloucester County, Northwest Hunterdon County and Walnut Valley). Such an obvious pattern of distribution is not apparent using CBC data presented on a continental scale (Bock and Lepthien 1976, Root 1988).

Habitat Relationships. The abundance of wetlands correlated significantly ($r = 0.61, N = 25, P < 0.002$) with the abundance of Rough-legged Hawks along the outer coastal plain (Fig. 1B), except for Monmouth county which is the most heavily populated county in this physiographic region (Robichaud and Buell 1973). However, the abundance of wetlands seems to be of less importance on the inner coastal plain and pinelands area (Gloucester and Burlington counties). This discrepancy is partially explainable based on the type of wetlands predominating in each region (Tiner 1985). The wetland percentages for outer coastal counties represent mostly broad expanses of open marsh environments (salt and freshwater) which are dominated locally by emergent vegetation such as cattail (*Typha* sp.), common reed (*Phragmites communis*), and several *Spartina* species. The physiognomy of these palustrine wetland habitats resembles the sedge, heath, and willow vegetational communities of the tundra that Rough-legged Hawks use for foraging during the nesting season (Smith et al. in press). A preference for open habitats by wintering Rough-legged Hawks has also been noted by others (Weller 1964, Schnell 1968, St. John 1980, Fischer et al. 1984) and is consistent with a species which spends each breeding season exclusively on the open tundra.

The abundance of Rough-legged Hawks in New Jersey decreased within the inner coastal plain and pinelands area (Gloucester and Burlington counties) despite the presence of wetlands. The predominant wetlands in these counties include wooded swamps and bogs (Tiner 1985), which may limit foraging opportunities for this open country raptor. Other inland and highland areas in northern New Jersey also yielded low counts of Rough-legged Hawks, most likely because these areas are extensively wooded and provide little open habitat.

Root (1988) found an association of Rough-legged Hawks with National Wildlife Refuges and attributed this to the availability of protected and managed environments within the refuge boundaries. Most wildlife areas that Root (1988) specifically noted center on or include important wetland components.

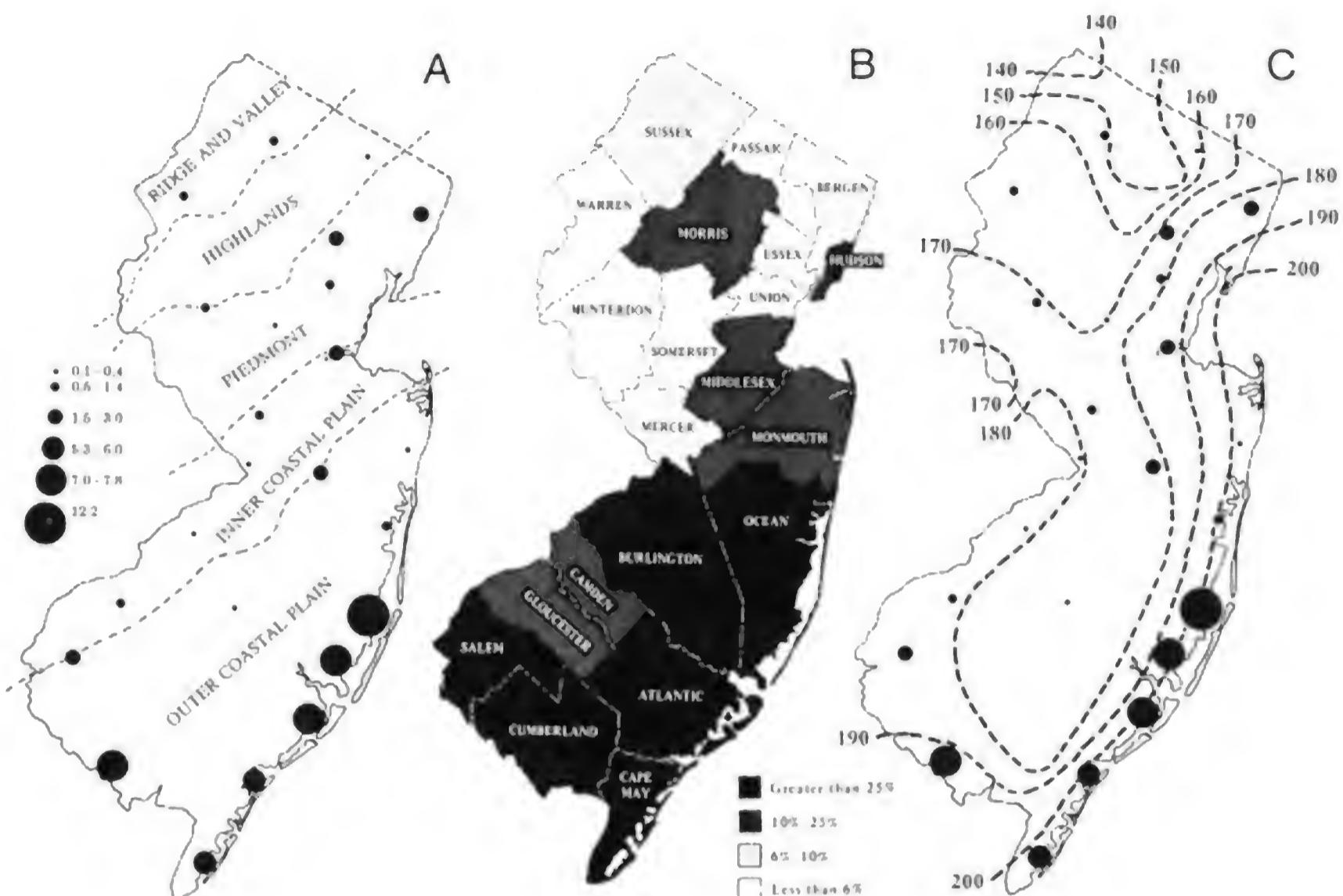


Figure 1. Winter Rough-legged Hawk abundance (birds per 1000 party-hours) from New Jersey Christmas Bird Counts in relation to A) physiographic regions, B) county wetland percentages (from Tiner 1985), and C) number of frost-free day isolines (Robichaud and Buell 1973).

Hence, Rough-legged Hawks may be responding to the structurally similar features of wetlands and tundra habitats rather than a protected and managed environment, especially since most New Jersey wetlands which are used by Rough-legged Hawks are heavily disturbed and modified. Our observations of Rough-legged Hawks wintering each year in the Hackensack Meadowlands, an inland tidal area characterized by large scale habitat alteration, industrialization, and high levels of human activity, suggest that this *Buteo* can tolerate a wide range of human disturbance and habitat alteration.

Climatic relationships. Despite its panboreal distribution, several researchers have noted that Rough-legged Hawks avoid snow cover on their wintering grounds (Schnell 1968, Watson 1986, Sonerud 1986). To examine the effect of winter climate, we compared the New Jersey Rough-legged Hawk distribution to the number of frost-free days (Fig.

1C). In this case, a positive correlation ($r = 0.55, N = 25, P < 0.005$) between hawk abundance and warmer climate was apparent. Root (1988) noted that this raptor is absent from regions where average minimum mid-January temperatures are below -6°C , or areas that receive less than 102 cm of precipitation per year. Frequent snow cover was also noted as a negative factor in Rough-legged Hawk distribution by Schnell (1968), Watson (1986) and Sonerud (1986). Most of these investigators have speculated that Rough-legged Hawks may have greater difficulties in prey detection and capture with significant snow cover.

Winter Population Trends. The winter abundance of Rough-legged Hawks in New Jersey often showed wide variations between years (Fig. 2A). Lowest numbers were recorded in 1956 and 1967 (1.5 and 1.6 hawks per 100 party-hours, respectively) and highest numbers in 1963 and 1964 (7.8 and 7.3,

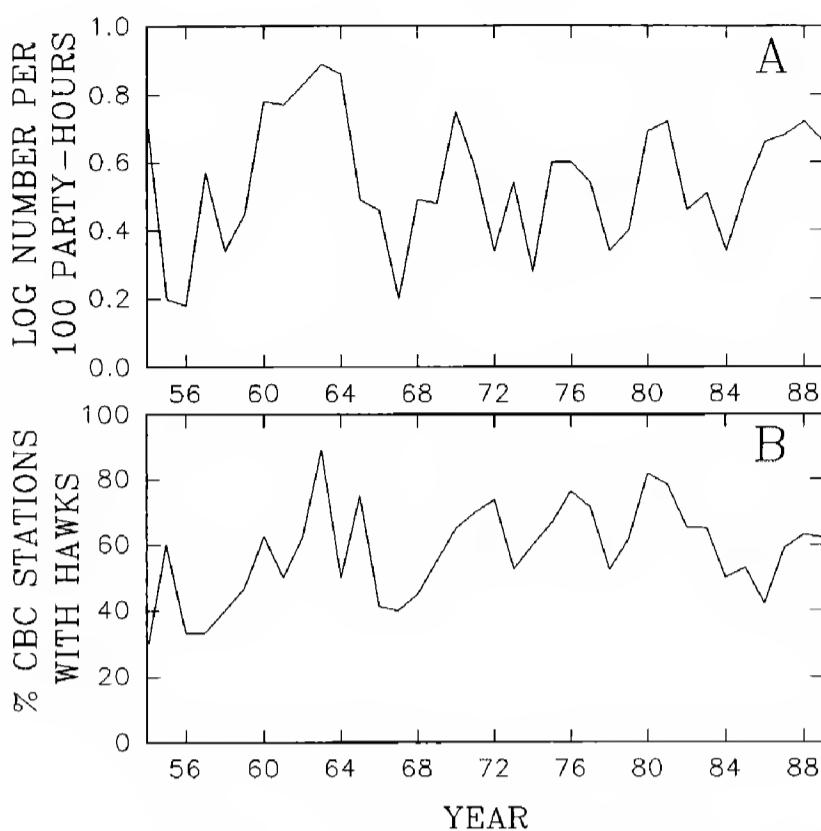


Figure 2. Winter population trends of Rough-legged Hawks from Christmas Bird Counts (1954-89) in New Jersey represented by A) the log number of birds per 100 party-hours and B) percent of CBC stations reporting Rough-legged Hawks.

respectively). No significant changes in population size were detected with linear regression analysis ($P > 0.4$), and the abundance of this *Buteo* during the 1980s did not differ appreciably from previous decades.

The percentage of CBC stations at which Rough-legged Hawks were recorded also showed wide variations (Fig. 2B), ranging from 27% in 1954 to 89% in 1963. The highest percentage of stations recording Rough-legged Hawks occurred during the winter of the hawk's greatest abundance, suggesting that Rough-legged Hawks were both abundant and widespread in that year. In other years, however, increases in Rough-legged Hawk abundance was a function of greater numbers of individuals at only a few stations and, overall, numbers of individuals recorded did not always track with the percentage of stations recording this *Buteo*.

Despite the sometimes dramatic changes in Rough-legged Hawk numbers between years, the overall wintering abundance of this species appears to remain steady in New Jersey. Titus et al. (1989) also noted an among-year variability and lack of pronounced changes in numbers of Rough-legged Hawks in the northeastern United States.

In conclusion, the southern New Jersey coastal areas provide open marsh habitats, warmer climate, and less persistent snow cover than highland areas. These factors may operate simultaneously in creating the proper habitat-climate gradient favored by wintering Rough-legged Hawks. Thus, the preservation of Atlantic coastal marshes is of critical importance in the conservation of the Rough-legged Hawk. Although populations of this wintering raptor do not appear to be in decline, the results of this paper suggest that continued destruction of U.S. coastal wetlands could be responsible for future declines in Canadian Rough-legged Hawk breeding populations.

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PREY USE BY EASTERN SCREECH-OWLS: SEASONAL VARIATION IN CENTRAL KENTUCKY AND A REVIEW OF PREVIOUS STUDIES

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ABSTRACT.—We examined prey use by Eastern Screech-Owls (*Otus asio*) in central Kentucky and reviewed the results of previous studies. Invertebrates and mammals were the most common prey in central Kentucky, with mammals and birds contributing the most biomass. Although prey use by screech-owls varied among other locations, small mammals or birds always contributed the most biomass. In central Kentucky and at other locations, invertebrates were frequently used during the breeding season. However, the small size of invertebrates limited their contribution to total prey biomass. Although capable of killing prey with masses greater than 100 g, screech-owls typically used much smaller prey ($\bar{x} = 28.3$ g). The mean mass of prey taken by screech-owls during the breeding period ($\bar{x} = 24.6$ g) was lower than during the non-breeding period ($\bar{x} = 31.8$ g), a result of the increased availability and use of smaller prey (e.g., invertebrates) during the breeding period.

Presas cazadas por tecolotes de la especie *Otus asio*: variación estacional en Kentucky central, y una revisión de estudios previos

EXTRACTO.—Hemos examinado el uso de las presas por tecolotes *Otus asio* en Kentucky central, y hemos revisado los resultados de estudios anteriores. Mamíferos e invertebrados fueron las presas más comunes en Kentucky central. La biomasa estuvo compuesta en su mayoría por mamíferos y aves. Aunque las presas del *O. asio* variaron según los sitios de caza, los pequeños mamíferos y las aves siempre contribuyeron mayormente a la biomasa. En Kentucky central y en otros sitios, los invertebrados fueron frecuentemente cazados durante la estación de reproducción; sin embargo, la pequeña dimensión de éstos limitó su contribución a la biomasa de presa total. Aunque tienen capacidad para matar presas con una masa de más de 100 g de peso, estos tecolotes cazaron presas típicamente más pequeñas ($\bar{x} = 28.3$ g). La masa media de la presa cogida por el *O. asio* durante el período reproductor ($\bar{x} = 24.6$ g) fue menor que la de la presa del período no reproductor ($\bar{x} = 31.8$ g). Esto es resultado del aumento en la disponibilidad de presas más pequeñas (e.g., invertebrados) durante el período de reproducción.

[Traducción de Eudoxio Paredes-Ruiz]

Although Eastern Screech-Owls (*Otus asio*) are among the most widespread raptors in eastern North America (Johnsgard 1988), relatively few data are available concerning their food habits (Marti and Hogue 1979). Most studies have been conducted in the northern United States and most authors have only reported the percentage of occurrence of each prey category. Using frequency data to draw conclusions about the relative importance of various prey may be misleading. Although such data may provide information about the relative impact a raptor has upon prey species, biomass determination may give a more accurate evaluation of the relative importance of prey species to the raptor (Marti 1987).

The objective of our study was to examine prey use, both in terms of occurrence and biomass, by Eastern Screech-Owls. We provide information concerning prey use in central Kentucky and compare our results with those published previously. Data from previous studies were reanalyzed, converting occurrence data into biomass data, so that occurrence and biomass data could be compared. We sought to determine the extent to which prey use by screech-owls varied with geographic location and with time of year.

METHODS AND MATERIALS

Prey Use by Screech-Owls in Central Kentucky. We determined prey use by identifying the remains of prey in pellets ($N = 351$) and nest debris ($N = 9$ nests), and by identifying cached items. Pellets and nest debris were collected from nests and roost sites at the Central Kentucky Wildlife Management Area, Madison County, Kentucky, between September 1985 and August 1986. Pellets were

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collected from open roost sites either on or one day after the day of use. Prey remains in nests and nest boxes were collected only when the site was vacant. Nest debris was collected from each nest site in May 1986 after young owls left the nest.

We identified and quantified most vertebrates using skulls and most invertebrates using head capsules. Some mammals and birds were identified using hair and feathers, and these prey were quantified by assuming the fewest possible number of individuals (e.g., feathers from one species were assumed to represent one individual). Crayfish remains in pellets were highly fragmented so we assumed that a pellet containing crayfish contained one individual. All prey items were identified to the lowest possible taxonomic category. We used Chi-square analyses to test for differences in frequency of use of different prey (invertebrates, fish, amphibians, birds and mammals), and to test for differences in prey use between the breeding (March through August) and non-breeding periods (September through February).

Estimating the Mass of Prey Items. The mass of some prey was estimated by weighing individuals captured on or near our study area (e.g., several invertebrates and several species of salamanders). Most estimates, however, were taken from the literature (Craighead and Craighead 1956, Burt and Grossenheider 1964, Carlander 1969, Barbour and Davis 1974, Marti 1974, Clench and Leberman 1978, Trautman 1981, Steenhof 1983, Dunning 1984, Kellner and Ritchison 1985). When the mass of a species or group was presented as a range (e.g., Burt and Grossenheider 1964), we used the midpoint as the estimated mass. The mass of some prey (e.g., unidentified thrush) was estimated based on the masses of closely related species (e.g., the mean mass of all thrush species). Although the mass of prey may vary with sex, age, and geographical location, it was not possible to adjust for these variables. Thus, the same estimate of mass was used for all individuals of a particular prey species or category, regardless of the geographic location of the study. The mass of some prey items was potentially (i.e., for older individuals) greater than that of an adult screech-owl (e.g., bluegill *Lepomis macrochirus* and Norway Rat *Rattus norvegicus*). We assumed that screech-owls would not take a prey item with a mass larger than their own (mean = 167 g for males and 194 g for females; Henny and VanCamp 1979) and assigned these potentially large prey items a mass of 150 g.

Terminology. Previous investigators have examined seasonal variation in prey use by screech-owls, however, these investigators have delimited seasons in different ways. We divided the year into two periods: breeding (March through August) and non-breeding (September through February). Thus, the breeding period includes the "nesting season" (Craighead and Craighead 1956, VanCamp and Henny 1975) and "spring" (Duley 1979), while the non-breeding period includes the "winter" (Craighead and Craighead 1956, Duley 1979), "fall and winter" (VanCamp and Henny 1975), and the "late fall and winter" (Cahn and Kemp 1930).

RESULTS

Prey Use by Screech-Owls in Central Kentucky.

Pellets, nest debris, and nest boxes yielded

671 prey items (Table 1). The number of prey items from the five prey groups (invertebrates, fish, amphibians, birds, and mammals) varied significantly ($\chi^2 = 865.7$, df = 4, $P < 0.0001$), with invertebrates and mammals being most numerous. Crayfish and beetles were the most common invertebrate prey. Short-tailed shrews (*Blarina brevicauda*), voles (*Microtus* spp.), and mice (*Peromyscus* spp.) were the most common mammalian prey. Mammals contributed the most biomass (65.9%), followed by birds (19.8%) and invertebrates (12.8%; Table 1).

Prey use varied significantly by period ($\chi^2 = 27.95$, df = 4, $P < 0.0005$), with more mammals taken by screech-owls during the non-breeding period and more invertebrates taken during the breeding period (this study; Table 2). Birds, fish, and amphibians were taken in similar frequencies during the two periods. Mammals contributed more biomass during the non-breeding (75.5%) than the breeding period (61.6%; Table 2). Despite being the most common prey during the breeding period (63.5% of all prey), invertebrates contributed only 15.5% of the total prey biomass (Table 1). During the non-breeding period, invertebrates contributed 7.7% of the total prey biomass (this study; Table 2).

Prey Use by Screech-Owls: a Review. Information concerning prey use was obtained from eleven studies (Table 2). Six were conducted in the northern part of the screech-owl's range (Ohio, Wisconsin, Illinois, New York and two in Michigan), four in the middle (Missouri, Tennessee and two in Kentucky), and only one in the southern part (Arkansas). These studies reported a total of 4917 prey items, including 20 species of mammals, 73 species of birds, 1 species of reptile, 8 species of amphibians, and 9 species of fish. Although most invertebrates were not identified to species, 35 families and genera were reported as screech-owl prey. Among the major prey groups, mammals (60.9%) were taken most frequently, followed by invertebrates (22.9%) and birds (14.4%; Table 2). Mammals (73.7%) and birds (19.5%) contributed the most biomass (Table 2). Invertebrates made up only 1.7% of the prey biomass (Table 2).

Rodents (93.6%) were the most frequently taken mammalian prey of screech-owls, followed by insectivores (6.1%) and bats (0.2%). Voles (*Microtus* spp., 69.2% of rodent prey) and mice (*Peromyscus* spp., 17.4% of rodent prey) were the most common rodent prey of screech-owls. Most avian prey were passerines (95.3%), largely in the families Emberi-

Table 1. Prey used by Eastern Screech-Owls in central Kentucky.

PREY	OCCURRENCE		BIOMASS	
	N	%	GRAMS	%
Mammals				
<i>Blarina brevicauda</i>	49	7.3	1127.0	11.2
<i>Cryptotis parva</i>	7	1.0	42.0	0.4
Unident. shrew	3	0.3	54.0	0.5
<i>Pipistrellus subflavus</i>	1	0.1	5.0	<0.1
<i>Glaucomys volans</i>	2	0.3	128.0	1.3
<i>Reithrodontomys humulis</i>	1	0.1	12.0	0.1
<i>Peromyscus leucopus</i>	3	0.3	66.0	0.7
<i>Peromyscus</i> spp.	39	5.8	858.0	8.5
<i>Microtus pennsylvanicus</i>	17	2.5	629.0	6.3
<i>Microtus ochrogaster</i>	12	1.8	516.0	5.1
<i>Microtus</i> spp.	28	4.2	1120.0	11.1
<i>Rattus norvegicus</i>	1	0.1	150.0	1.5
<i>Mus musculus</i>	11	1.6	209.0	2.1
Unident. cricetid/murid	39	5.8	1092.0	10.8
Unident. rodent	18	2.7	630.0	6.3
Mammal subtotal	231	34.5	6638.0	65.9
Birds				
<i>Cyanocitta cristata</i>	5	0.7	435.0	4.3
<i>Sialia sialis</i>	2	0.3	64.0	0.6
<i>Turdus migratorius</i>	1	0.1	77.0	0.8
Unident. warbler	1	0.1	10.0	0.1
<i>Quiscalus quiscula</i>	2	0.3	228.0	2.3
<i>Cardinalis cardinalis</i>	6	0.9	264.0	2.6
<i>Pipilo erythrrophthalmus</i>	3	0.4	123.0	1.2
Unident. passerine	17	2.5	680.0	6.8
Unident. bird	2	0.3	112.0	1.1
Bird subtotal	39	5.8	1993.0	19.8
Amphibians				
Unident. salamander	1	0.1	3.5	<0.1
<i>Rana</i> spp.	1	0.1	30.0	0.3
Fish				
<i>Notropis chryscephalus</i>	9	1.3	117.0	1.2
Amphibian/fish subtotal	11	1.6	150.5	1.5
Insects				
Acrididae	26	3.9	39.0	0.4
Tettigoniidae	2	0.3	3.0	<0.1
Unident. orthopteran	2	0.3	2.0	<0.1
Carabidae	30	4.5	6.0	<0.1
Scarabaeidae	2	0.3	0.6	<0.1
Tenebrionidae	2	0.3	1.2	<0.1
Unident. coleopteran	123	18.3	36.9	0.4
Pentatomidae	2	0.3	0.4	<0.1
Apidae	3	0.4	1.2	<0.1
Noctuidae	2	0.3	2.0	<0.1
Unident. insect	11	1.6	16.5	0.2

Table 1. Continued.

PREY	OCCURRENCE		BIOMASS	
	N	%	GRAMS	%
Crustaceans				
Astacidae				
<i>Cambarus</i> spp.	10	1.5	65.0	0.6
Unident. crayfish	172	25.6	1118.0	11.1
Arachnids				
Unident. spider	1	0.1	0.5	<0.1
Gastropods				
Polygridae	2	0.3	0.8	<0.1
Invertebrate subtotal	390	58.1	1293.1	12.8
Overall total				
	671	100.0	10 074.6	100.0

Table 2. Summary of prey use by Eastern Screech-Owls.

LOCATION ^a	PERIOD ^b	PERCENT OCCURRENCE				PERCENT BIOMASS				PREY ITEMS	METHOD ^d		
		MAM- MALS	BIRDS	IN- VERTS.	REP- TILES	FISH, AMPHIB- IANS, AND		FISH, AMPHIB- IANS, AND					
						MAM- MALS	BIRDS	IN- VERTS. ^c	REP- TILES				
Michigan-1	NB	91.9	7.7	0.4	0	89.8	10.2	*	0	235	P		
Michigan-1	B	46.2	16.9	36.9	0	62.2	29.9	7.9	0	65	P		
Michigan-2	Sept.-May	99.3	0.3	0.4	0	99.5	0.4	0.1	0	1549	P		
Wisconsin	all	68.6	26.3	2.2	2.9	71.6	18.0	0.4	10.0	137	P		
New York	B	6.1	36.1	48.4	9.4	27.1	45.0	7.9	20.0	213	C, P, O		
Ohio	B	30.4	64.8	0.8	4.0	27.1	59.8	0.1	13.0	477	C		
Ohio	NB	60.3	26.5	2.5	10.7	50.5	29.3	0.3	19.8	121	C		
Illinois	NB	92.2	7.8	0	0	89.6	10.4	0	0	128	P		
Missouri	all	92.4	7.0	0.4	0.2	92.1	7.7	*	0.2	497	P		
Kentucky-1	all	14.7	14.8	70.5	0	39.1	56.4	4.5	0	244	S, P		
Kentucky-2	B	29.0	5.6	63.5	1.9	61.6	21.0	15.5	1.9	203	P, C		
Kentucky-2	NB	49.3	5.9	43.8	1.0	75.5	16.1	7.7	0.7	468	P, C		
Tennessee	B	16.5	63.7	9.9	9.9	10.8	68.2	0.6	20.4	91	C		
Tennessee	NB	4.2	72.9	6.2	16.7	1.9	65.1	0.5	32.5	48	C		
Tennessee	all	4.7	1.2	93.1	1.0	49.8	15.2	18.7	16.3	407	S		
Arkansas	all	8.8	8.8	76.5	5.9	18.5	57.3	12.4	11.8	34	S		
Overall		60.9	14.4	22.9	1.8	73.7	19.5	1.7	5.1	4917			

^a References = Michigan-1, Craighead and Craighead 1956; Michigan-2, Wilson 1938; Wisconsin, Errington 1932; New York, Allen 1924; Ohio, VanCamp and Henny 1975; Illinois, Cahn and Kemp 1930; Missouri, Korschgen and Stuart 1972; Kentucky-1, Brown 1989; Kentucky-2, this study; Tennessee, Duley 1979; Arkansas, Hanebrink et al. 1979.

^b NB = non-breeding period, B = breeding period, and all = all year.

^c * = less than 0.1%.

^d C = cached prey, P = pellets, O = direct observation, S = stomach contents.

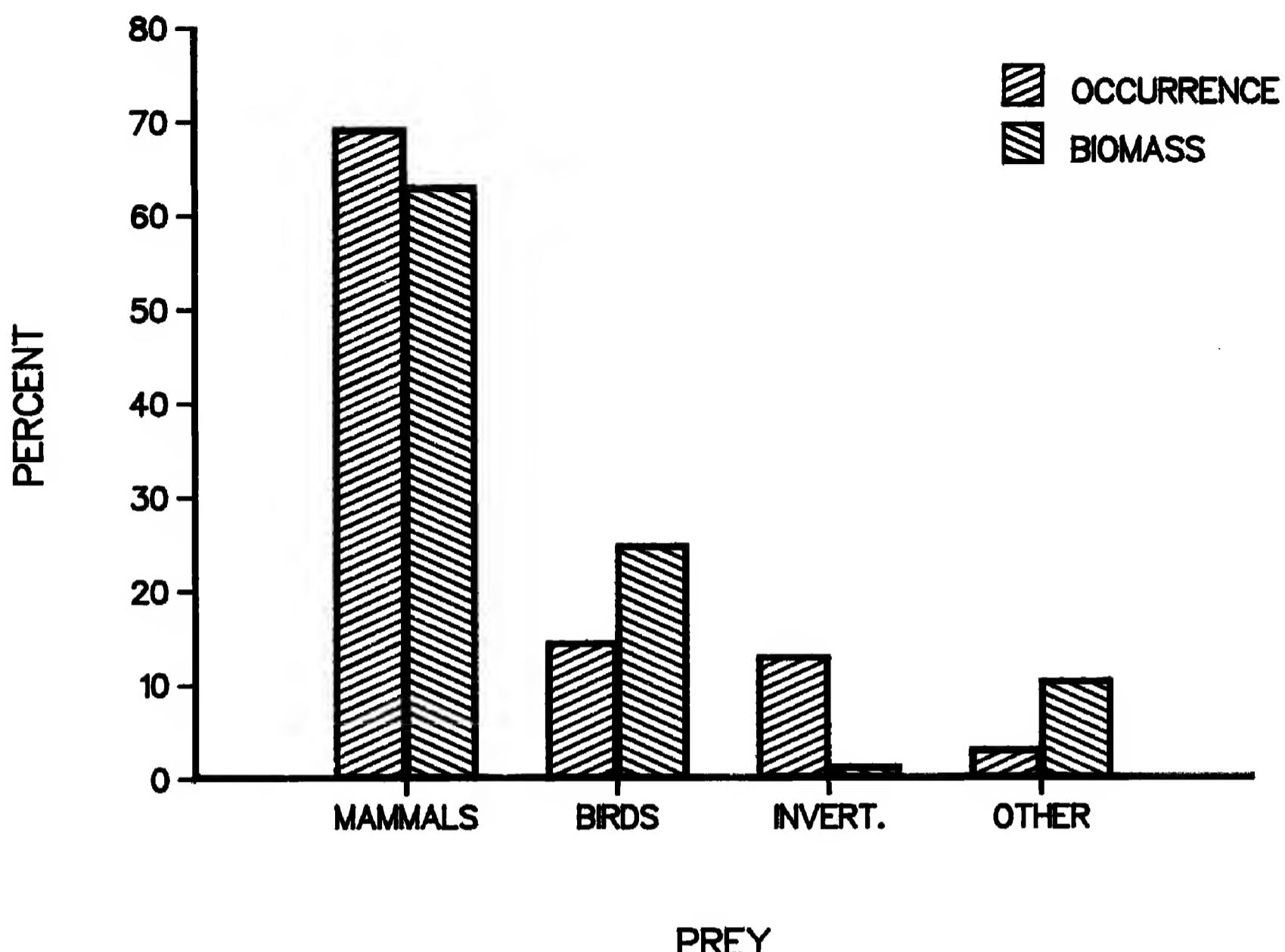


Figure 1. Prey use ($N = 735$) by Eastern Screech-Owls during the non-breeding period using data derived from several studies.

zidae (47.3% of passerines), Muscicapidae (12.1% of passerines) and Passeridae (9.6% of passerines). The most common invertebrate prey were crayfish (24%), moths and butterflies (26.6%), beetles (23.8%), and crickets and grasshoppers (15.3%).

Several investigators have reported seasonal variation in prey use by screech-owls (Table 2). Craighead and Craighead (1956) found that screech-owls in Michigan used mammalian prey almost exclusively during the non-breeding period but used a variety of prey (mammals, birds, and invertebrates) during the breeding period (Table 2). On the basis of cached prey, VanCamp and Henny (1975) found that small mammals were the most common prey of screech-owls during the non-breeding period (October–February) while birds were the most common prey during the breeding period (March–June; Table 2). VanCamp and Henny (1975) also examined

seasonal variation in the diet of screech-owls in the northeastern United States and Ontario, Canada, using stomach content data. Analysis revealed that 61% of the screech-owl stomachs collected during April through November contained arthropod (primarily insect) remains while only 18% of the stomachs collected during December through March contained arthropod remains.

For all studies providing seasonal data combined (Allen 1924, Cahn and Kemp 1930, Craighead and Craighead 1956, VanCamp and Henny 1975, Duley 1979, this study), the most common prey (both in frequency of occurrence and biomass) during the non-breeding period were mammals (Fig. 1) while the most common prey during the breeding period were birds (Fig. 2). Invertebrates were preyed upon more frequently during the breeding period (33.3% of all prey; Fig. 2) than during the non-breeding

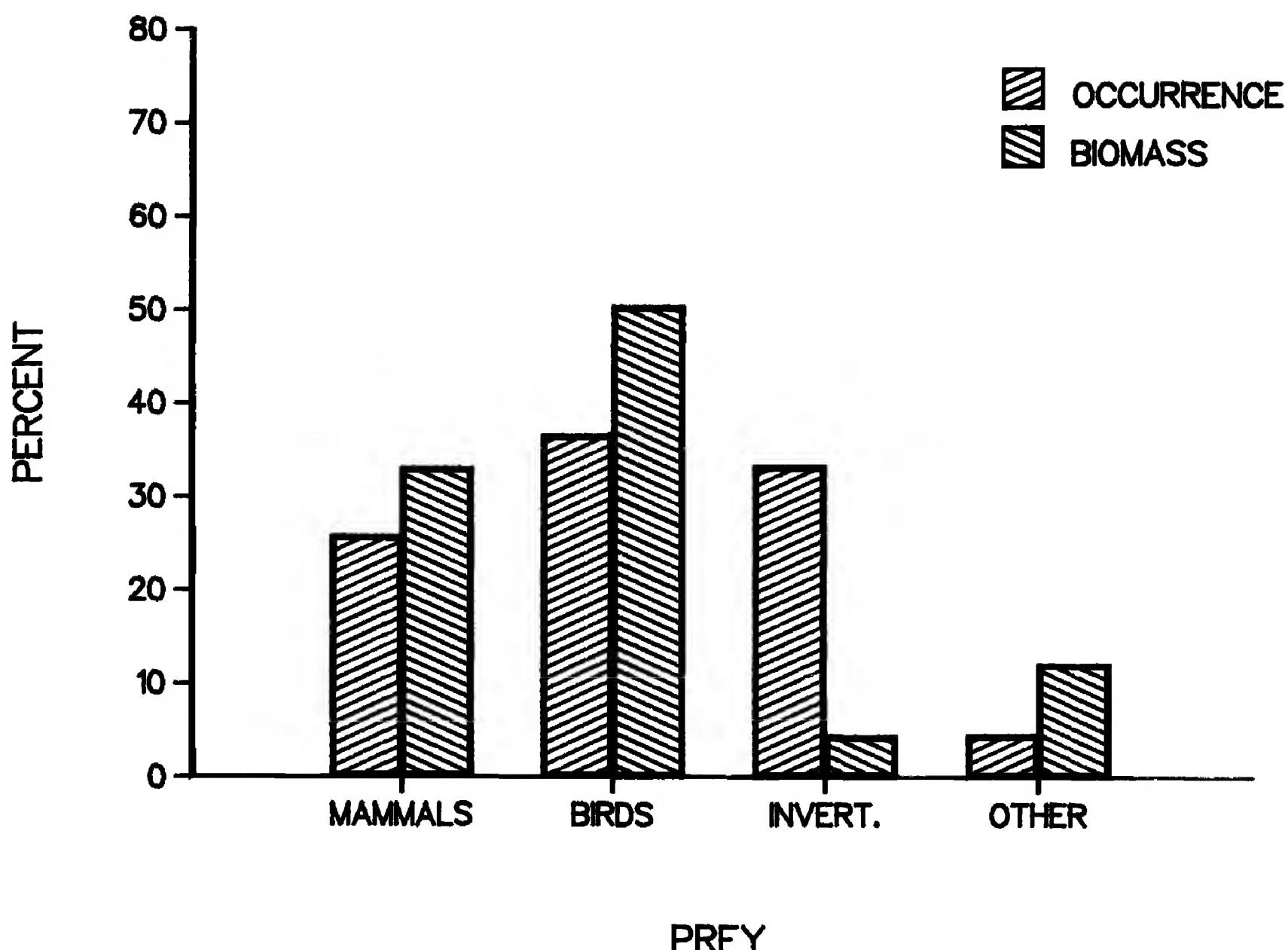


Figure 2. Prey use ($N = 1314$) by Eastern Screech-Owls during the breeding period.

period (Fig. 1), but only accounted for 4.4% of total prey biomass (Fig. 2).

Prey use by screech-owls varied with location (Table 2), however, differences in methodology and the time and duration of studies were probably responsible for some of this variation. Among studies using similar methods (examining pellets and cached prey) and timing (all or most of the year), mammals were predominant at both northern (Wisconsin, Errington 1932; Michigan, Craighead and Craighead 1956; Ohio, VanCamp and Henny 1975) and more southern (Missouri, Korschgen and Stuart 1972; Tennessee, Duley 1979; Kentucky, this study) locations (Table 2). These studies also suggest that birds were used more frequently by screech-owls at northern locations and invertebrates more frequently further south. However, these results were due largely to just two studies (VanCamp and Henny 1975, this

study). Other differences between locations were also apparent. For example, few invertebrates were used by screech-owls in Missouri (Korschgen and Stuart 1972) while many were used by screech-owls in central Kentucky (this study; Table 2).

The mean mass of all prey ($N = 4917$) taken by screech-owls was 28.29 ± 0.33 (SE) g. During the non-breeding period, the mean mass of screech-owl prey ($N = 735$) was 31.77 ± 0.88 g. During the breeding period, the mean mass of prey ($N = 1314$) taken by screech-owls was 24.61 ± 0.90 g. The mean mass of prey items in each of the major prey groups was 34.27 ± 0.26 g for mammals ($N = 2992$), 38.23 ± 1.02 g for birds ($N = 708$), 31.50 ± 6.93 g for amphibians ($N = 34$), 106.34 ± 7.81 g for fish ($N = 56$), and 2.12 ± 0.05 g for invertebrates ($N = 1126$). The mean mass for fish is relatively high because six of nine species reported as prey are po-

tentially larger than screech-owls and, therefore, were assigned a mass of 150 g.

DISCUSSION

Prey use by Eastern Screech-Owls may vary with season and location, but our results indicate that small mammals and birds contribute the most biomass. Invertebrates were sometimes taken more frequently than other prey (e.g., Allen 1924, VanCamp and Henny 1975, Duley 1979, Brown 1989, this study), however, the small size of most invertebrates limited their contribution to total prey biomass.

Invertebrates were taken more frequently by screech-owls during the breeding period than during the non-breeding period (Craighead and Craighead 1956, VanCamp and Henny 1975, Duley 1979, this study). Increased use of invertebrates by screech-owls during the breeding period may be due to increased availability at this time. Screech-owls at northern locations also took birds more frequently during the breeding period (e.g., Allen 1924, Craighead and Craighead 1956, VanCamp and Henny 1975). No seasonal variation in the number of birds in the diet of screech-owls was found in either Kentucky (this study) or Tennessee (Duley 1979). Increased use of birds by screech-owls during the breeding period at northern locations may be due to the increased availability of birds plus the reduced availability of other prey. Craighead and Craighead (1956:289) reported that "meadow mice and all other prey species, with the exception of the small-bird group, reached a period of minimum population density in spring" in Michigan. VanCamp and Henny (1975:18) suggested that the breeding period of screech-owls in northern Ohio was "timed to take advantage of the spring migration of small birds." Prey availability may fluctuate less at more southern locations, with ectotherms more likely to be available throughout the year. Thus, screech-owls further south (e.g., Kentucky and Tennessee) may not be as dependent on the influx of small birds that occurs during spring migration.

Differences in methodology were responsible for some of the variation reported in prey use by screech-owls. For example, birds were the most frequent prey of screech-owls during the breeding period in northern Ohio (VanCamp and Henny 1975) while invertebrates were the most frequent prey of screech-owls during the breeding period in New York (Allen 1924). However, VanCamp and Henny (1975) described food habits based solely on prey cached in

nest boxes, while Allen (1924) used cached prey, pellets, and direct observations. Screech-owls rarely cache small prey items like invertebrates (VanCamp and Henny 1975), explaining the apparent near absence of invertebrates in the diet of screech-owls in northern Ohio. Similarly, Duley (1979) reported few invertebrates (less than 10% of all prey items) in the diet of screech-owls when examining cached prey but found many invertebrates (more than 90%) when using stomach content analysis (Table 2).

Some differences in prey use between locations may be due to differences in prey availability. For example, although screech-owls rarely preyed on crayfish at other locations (see references in Table 2), we found that crayfish were frequently used by screech-owls in central Kentucky. Our study site is a low, poorly drained area (see Belthoff 1987 for a description of the area) supporting large numbers of terrestrial crayfish (*Cambarus* spp.) (pers. observation).

Our overall estimate of the mean mass of prey used by Eastern Screech-Owls was 28.3 g, and mean prey mass was lower for the breeding period than for the non-breeding period. Based on previous studies of screech-owl food habits, Marti and Hogue (1979) estimated a mean prey mass of 38.1 g. Differences in estimates of the mass of prey items may have contributed to this difference. In addition, however, we used data from more recent studies conducted in the southern United States (Duley 1979, Hanebrink et al. 1979, this study). These studies revealed greater use of smaller prey (invertebrates) by screech-owls than previous studies and, as a result, our overall estimate of mean prey mass was lower. Similarly, our estimate of mean prey mass was lower during the breeding period than the non-breeding period because of an increased use of invertebrates.

Although capable of killing prey with masses greater than 100 g, our results indicate that Eastern Screech-Owls typically use much smaller prey. Similarly, Marti and Hogue (1979) found that captive screech-owls offered lab mice of various sizes usually selected smaller prey over larger. There are several reasons why screech-owls may select smaller prey: 1) more small prey species are available, 2) smaller prey are likely younger and more vulnerable, 3) capturing larger prey may require greater energy expenditure if such prey escape more often, 4) risk of injury may be greater with larger prey, and 5) sit-and-wait predators like screech-owls expend lit-

tle energy in searching and may be able to afford to take smaller, easier prey (Marti and Hogue 1979).

Our results indicate that Eastern Screech-Owls use a wide variety of prey, with vertebrates predominant in terms of biomass, and, furthermore, that prey use varies with time of year. These conclusions, however, are based largely on studies conducted at northern locations, many of which focused on prey use by screech-owls during the non-breeding period, when owls roost in natural or artificial boxes and prey remains are easier to locate. In addition, techniques used to examine prey use by screech-owls may overemphasize the importance of certain types of prey. Studies of prey use by screech-owls relying more on either stomach content analysis or direct observation and conducted during the breeding period and in the southern part of their range may yield different results.

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SOCIAL HUNTING IN BROODS OF TWO AND FIVE AMERICAN KESTRELS AFTER FLEDGING

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ABSTRACT.—Young American Kestrels (*Falco sparverius*) presumably learn hunting skills during the first 4–6 wk after fledging. Imitative social hunting during this period may provide an adaptive advantage later in the juvenile period, if there is sufficient selection for learned efficiency in hunting. We report the results of a test of the hypothesis that imitative hunting in large broods increases hunting efficiency of American Kestrels after fledging. We experimentally adjusted the size of kestrel broods prior to fledging to two or five young. No differences in hunting efficiency were detected during the 4 wk of observation. Sample sizes, however, were small because of high mortality or signal failure among radio-marked birds. Most deaths occurred during the first week after fledging, and predation was the main cause of mortality.

Cacería en sociedad de dos a cinco crías de Halcón Cernícalo (*Falco sparverius*), después de haber dejado el nido

EXTRACTO.—Se supone que el Halcon Cernícalo (*Falco sparverius*) joven, aprende la destreza en la cacería durante las primeras 4–6 semanas después de haber dejado el nido. La imitación, implícita en cacerías sociales, puede proveer una ventaja en la adaptación posterior del período juvenil, si es que hay suficiente selección de eficiencia aprendida. Informamos los resultados de una prueba sobre la hipótesis de que la caza imitativa, en jóvenes de nidadas grandes, aumenta la eficiencia en cazar del Halón Cernícalo después de haber dejado el nido. Experimentalmente, a la nidadada de estos halcones, la hemos ajustado a un tamaño entre dos y cinco crías antes de que hayan salido del nido. No se detectaron diferencias en la eficiencia en cazar durante las 4 semanas de observación. Los tamaños de las muestras, sin embargo, fueron pequeñas debido a la alta mortalidad, o a la falla del equipo en las aves marcadas con radiotransmisores. La mayoría de las muertes acurrió durante la primera semana después de haber dejado el nido. La predación fue una causa principal de la mortalidad.

[Traducción de Eudoxio Paredes-Ruiz]

Wilson (1975:51) described two types of social hunting, imitative and cooperative. During imitative hunting individuals observe others and may initiate, copy, increase, or learn hunting behavior. According to Wilson, “the animal simply goes where the group goes, and eats what it eats.” Cooperative hunters usually use a signal (or signals) to coordinate pursuit, whereas during imitative hunting, communication is thought to be without signals and group members do not divide labor (Hector 1986). Several investigators have reported feeding benefits associated with imitative hunting (e.g., Krebs 1973, Rubenstein et al. 1977, Sullivan 1984, Edwards 1989a, 1989b). Edwards (1989a, 1989b) compared the hunting behavior of sibling pairs of Ospreys (*Pandion haliaetus*) and singletons, and found that pairs

developed hunting skills sooner, used similar hunting techniques, and had similar diets.

Hector (1986) reported that imitative hunting (as defined by Wilson) is more common than cooperative hunting among raptors, and he cited several examples of species that hunt in this manner. Kellner (1990) observed imitative hunting in one sibling group of five kestrels, and among three of these siblings and five other juveniles. Other anecdotal accounts of imitative hunting include observations of up to 20 juveniles hunting in a single field (Cade 1955), 18 juveniles “perched along one short stretch of road” (Wheeler 1979), and aggregations of as many as 14 juveniles and adults on reclaimed surface mines (Wilmers 1982).

In 1988 we began a study of the post-fledging

Table 1. Percent time (mean percent \pm SE) engaged in 10 behaviors by broods of two and five American Kestrels at weekly intervals after fledging in Iowa.

BEHAVIOR	BROOD SIZE	WEEKS POST-FLEDGING				1-4 P-VALUES ^a			
		1		2		3		4	
		MEAN \pm SE	MEAN \pm SE	MEAN \pm SE	MEAN \pm SE	MEAN \pm SE	MEAN \pm SE	BROOD SIZE	TIME \times BROOD SIZE
(N) ^b	2	(8)	(5)	(5)	(5)	(3)			
	5	(8)	(8)	(7)	(7)	(7)			
Perch resting	2	77.4 \pm 6.1	63.5 \pm 7.7	34.2 \pm 9.7	21.0 \pm 10.0	0.473	<0.001	0.156	
	5	78.2 \pm 4.6	69.4 \pm 3.5	46.3 \pm 4.2	39.0 \pm 9.2				
Perch hunting	2	0.0	5.6 \pm 5.6	42.4 \pm 15.9	56.4 \pm 11.0	0.263	<0.001	0.231	
	5	0.0	4.2 \pm 3.0	24.5 \pm 6.0	39.1 \pm 11.0				
Ground hunting	2	0.0	0.6 \pm 0.6	1.0 \pm 1.0	0.5 \pm 0.4	0.455	0.231	0.754	
	5	0.0	1.2 \pm 1.1	1.3 \pm 0.8	1.5 \pm 0.8				
Flying	2	0.3 \pm 0.2	7.0 \pm 5.6	7.3 \pm 4.2	2.5 \pm 1.5	0.375	0.168	0.857	
	5	0.2 \pm 0.2	2.8 \pm 0.7	4.3 \pm 2.0	3.5 \pm 1.2				
Eating self-captured prey	2	0.0	0.4 \pm 0.3	2.4 \pm 0.7	7.4 \pm 4.1	0.061	<0.001	0.152	
	5	0.0	0.1 \pm 0.1	0.3 \pm 0.1	3.5 \pm 1.4				
Maintenance	2	17.1 \pm 4.2	8.8 \pm 3.3	8.2 \pm 3.0	4.0 \pm 2.4	0.160	0.003	0.775	
	5	14.4 \pm 3.8	9.0 \pm 2.2	11.7 \pm 2.1	7.5 \pm 1.8				
Lying on belly	2	2.8 \pm 2.2	7.6 \pm 6.8	0.0	0.0	0.225	0.938	0.804	
	5	0.2 \pm 0.1	<0.1 \pm <0.1	0.0	0.0				
Begging	2	1.7 \pm 1.1	0.7 \pm 0.7	1.1 \pm 0.7	0.0	0.284	0.326	0.379	
	5	3.5 \pm 1.3	3.8 \pm 1.7	3.2 \pm 1.9	1.1 \pm 0.7				
Out of sight	2	0.2 \pm 0.2	3.0 \pm 1.8	3.1 \pm 1.5	7.6 \pm 4.9	0.069	0.394	0.326	
	5	3.4 \pm 2.0	9.2 \pm 3.1	7.5 \pm 2.7	3.7 \pm 1.3				
Other	2	0.6 \pm 0.4	2.9 \pm 1.9	0.2 \pm 0.2	0.7 \pm 0.7	0.628	0.889	0.326	
	5	<0.1 \pm <0.1	<0.1 \pm <0.1	0.9 \pm 0.9	1.2 \pm 1.0				

^a ANOVA for brood size, time and time \times brood size across 4 wk post-fledging (df = 1, 28). All tests for nonlinearity were not significant.^b Total number of broods of two and five siblings observed.

behavior of American Kestrels (Varland et al. 1991). We quantified the occurrence of imitative hunting among siblings and between siblings and other kestrels. In this paper, we report the results of a test of the hypothesis that imitative social hunting in large broods increases hunting efficiency.

STUDY AREA AND METHODS

We studied a population of wild kestrels nesting in 27 nest boxes in central Iowa in 1990. A total of 24 nest boxes was attached to highway signs along Interstate Highway 35. Two nest boxes were located on farmsteads, and one was located at the College of Veterinary Medicine at Iowa State University, Ames, Iowa.

We banded all 90 young with U.S. Fish and Wildlife Service leg bands and individually marked them with colored vinyl leg jesses prior to fledging. Jesses were made with Norcross virgin vinyl (Norcross Industries Inc., West Palm Beach, FL) strips 6.5 cm long, 1.4 cm wide and

riveted together, leaving a trailing tab about 3.5 cm in length.

In order to create broods of five and broods of two young, the size of broods was adjusted 1–3 d before the oldest bird in the brood fledged. Natural broods of five young were left intact and broods of <5 young were reduced to broods of two. In only two instances was it necessary to add birds to a brood; one kestrel was added to a brood of one and one was added to a brood of four. The age of these introduced young was matched closely with the age of young already in these nests. All young removed from nests, except the two introduced into broods, were released by hacking (see Barclay 1987:243) at the Iowa Department of Natural Resources Wildlife Research Station near Boone, Iowa. These adjustments resulted in 15 broods of 2 siblings each and 12 broods of 5 siblings each (Table 1).

We used backpack radiotransmitters from Holohil Systems, Ltd., Woodlawn, Ontario, Canada. Radiotransmitters were attached to one randomly selected individual in each of the 12 broods of 2; both individuals were radio-

tagged in three broods. Among broods of five, one individual was radiomarked in each of nine broods and five, four, and two individuals were radiomarked in each of the other three broods.

Only kestrels fitted with radiotransmitters were selected for observation as focal birds (Altmann 1974). When >1 individual in a brood was radiomarked, one fledgling was randomly selected for observation from among those visible.

Fledglings were observed between 0600–1300 H at a distance of 70–100 m with a 20 \times or 20–60 \times spotting scope. Family groups were monitored on a rotational basis; generally once during the first week after fledging and then at 1–3 d intervals until contact with all radiomarked kestrels in a brood was lost. When we could not find a radiomarked kestrel, we searched by vehicle an area of about 64 km² around the kestrel's last known location.

Nine radiomarked kestrels in eight small sibling groups died within 1 wk after fledging. During the first 2 wk after fledging, five radiotagged kestrels from five large sibling groups also died. Signals failed in five transmitters, two in small sibling groups and three in large, within 3 d after the radio-tagged birds fledged.

We adopted Wyllie's (1985) definition of dispersal, which is movement of a fledged bird farther than 1 km from its nest without return. We determined time of dispersal only for kestrels with transmitters known to be functioning 1 wk after fledging. Birds whose signal was lost <1 wk after fledging ($N = 5$) were not classified as dispersed because young kestrels at this age are relatively inactive (Varland et al. 1991). Transmitter failure was confirmed in two of these five birds when they were observed with other radiomarked siblings. Thus, it was unlikely that signal loss in the other three birds was the result of movement from the search area.

Observation sessions lasted 5 to 60 min or until the focal bird disappeared from view. We did not use data if visual contact with the bird was lost in <5 min. We attempted to initiate a second observation session with the same focal bird or with another radiomarked kestrel from the brood if the bird disappeared in 5–30 min. This resulted in a total of 15 paired sessions. For the analysis, we combined each pair of consecutive sessions into one session. We analyzed data for 85 observation sessions (mean length = 43.6 min, SD = 19.6).

A metronome timing device (Wiens et al. 1970) set at 20-sec intervals cued spot observations of behavior and social activity. At each sound of the tone, we recorded behavior and social activities of the focal kestrel. Except for the social activity subclass "social hunting," we used the classes and subclasses of activity described in Varland et al. (1991): general behavior (nine subclasses), social behavior (five subclasses), hunting behavior, and allopreening and beaking.

General Behavior. "Perch resting" describes a kestrel perched and not engaged in any other behavior. "Perch hunting" was distinguished from other perching activity by alert posture, erect body or body leaning slightly forward, frequent staring at ground, and head bobs (Toland 1987, Village 1990). "Ground hunting" was defined as a bird searching on the ground for prey for >20 sec. Searches of shorter duration involving flight from a perch were

recorded as perch hunting. "Flight" was any nonhunting flight. We used the term "eating" only for kestrels eating self-captured prey. "Maintenance activity" included preening, plumage rousals (shaking), and stretching. "Lying-on-belly" describes a posture young kestrels often assumed on fenceposts, utility poles, and large tree branches. "Begging" was solicitation of food from parents. "Out-of-sight" referred to a focal kestrel concealed by vegetation or other objects. A session was discontinued when a bird was out of sight >5 min. "Other" was used to categorize behaviors observed relatively infrequently: walking, hover hunting, aggressive interactions among siblings, parent-to-young prey transfers, and eating prey caught by parents. It was not uncommon for one or both adults to vocalize aggressively at observers during observation sessions (see also Varland et al. 1991). Thus, interactions between broods and parents probably occurred less frequently than they would in the absence of observers.

Social Behavior. "Association" was any activity (except social hunting) of the focal kestrel that occurred ≤ 3 m from one or more siblings (kestrels other than siblings were sometimes included, see Varland et al. 1991). "Non-social" refers to activity of the focal kestrel occurring >3 m from one or more kestrels. When we could not see whether other kestrels were ≤ 3 m from the focal kestrel because of dense vegetation, we recorded the kestrel's social status as "undetermined." "Social hunting" was hunting activity by the focal kestrel which occurred ≤ 10 m from one or more kestrels that were also hunting. This social hunting distance was increased from ≤ 3 m (Varland et al. 1991), because we observed that social interactions among hunting kestrels could occur at distances of up to 10 m.

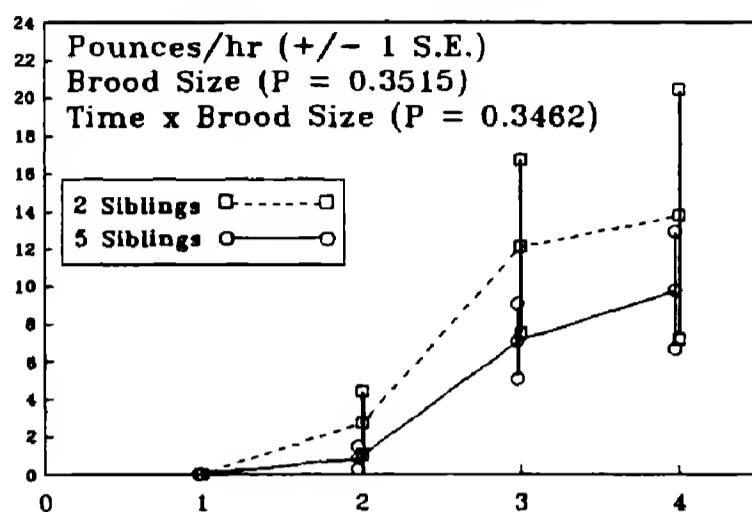
Hunting Behavior. We recorded number of pounces, number of captures, and prey type. Hunting success was the percentage of pounces with known outcomes that were successful. Outcomes were unknown in 15% (46/310) of the observed pounces. In these cases, either the capture phase of prey pursuit occurred out of sight or the pursuit occurred too far away and we were unable to determine the outcome. Pounces were converted to hourly rates based on session length.

Allopreening and Beaking. We recorded the frequencies and the individuals involved in allopreening and beaking (Varland et al. 1991), forms of direct social contact.

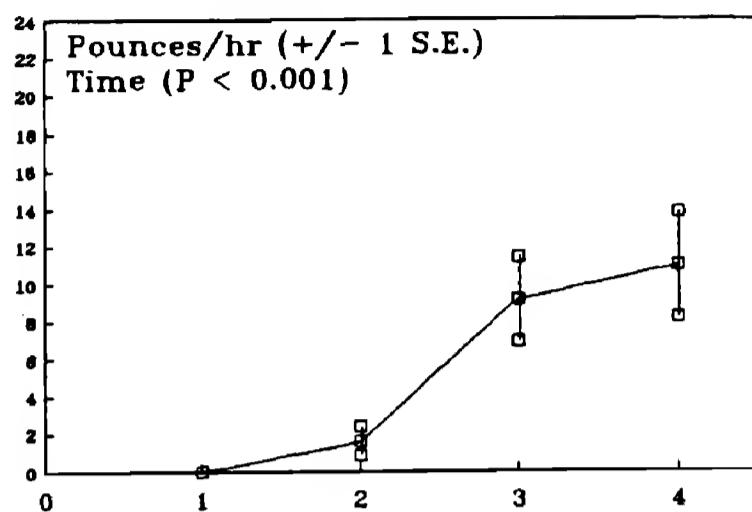
Statistical Analyses. We grouped behavioral data by 7-d intervals starting with fledging. The experimental unit (n) was the sibling group, and the number of groups observed during each of the 4 wk that birds were under study ranged from eight to seven for sibling groups of five and from eight to three for sibling groups of two. We computed statistics for behavior, social, and hunting activity for each sibling group in each 7-d post-fledging interval for which data were available.

We used the general linear model procedure (PROC GLM, SAS Institute 1985) for an analysis of variance (ANOVA). The split-plot approach to repeated measures was used (Winer 1971) to test for differences in behavior, social, and hunting activities between large and small sibling groups of kestrels. Thus, for specific activities during the 4 wk after fledging, we conducted tests for average brood size effect, for linear trends over time, and for dif-

(a) Two and five sibling groups



Groups combined



(b)

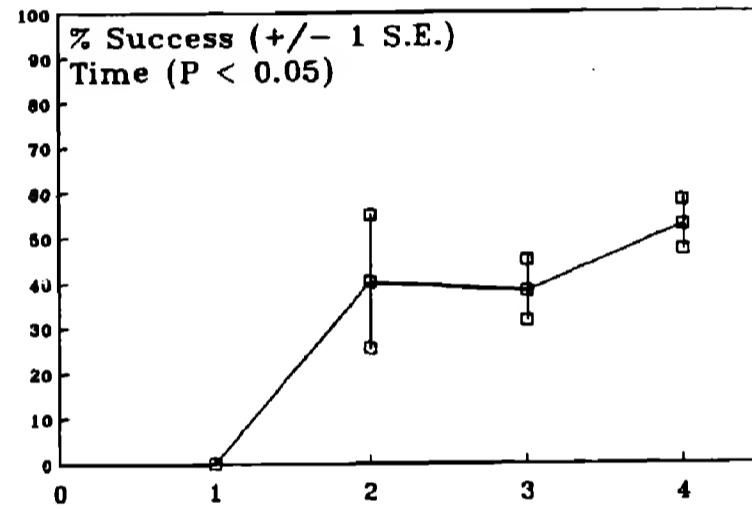
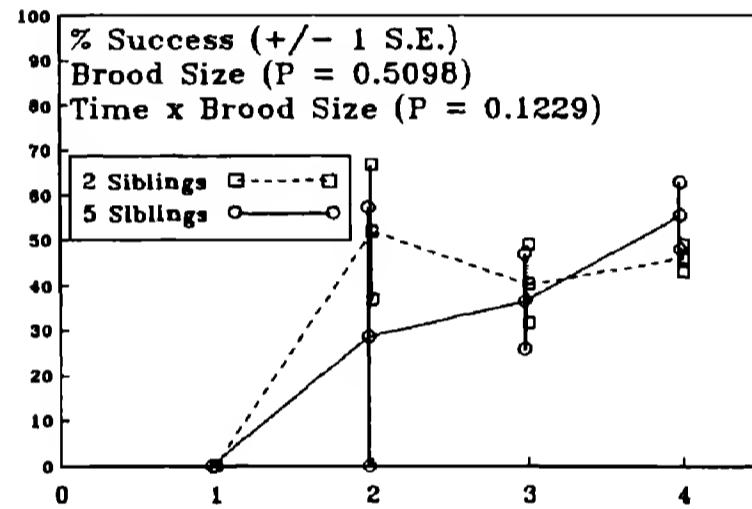


Figure 1. Mean (\pm SE) pounces/hr (a) and percent success (b) for sibling groups of two and five American Kestrels (left) and for groups combined (right) at weekly intervals after fledging. ANOVA for brood size, time \times brood size and time effects across 4 wk post-fledging (df = 1, 28). All tests for nonlinearity were not significant.

ferences in the rates of development (TIME \times BROOD SIZE interaction). Because data were missing from some cells (not all sibling groups were represented in all weeks), we used Type III sum of squares to calculate *P*-values. We selected 0.05 as the level of significance for linear time trends in behavior. Because tests of several behaviors were considered in each phase of analysis, the significance level of *P*-values was adjusted using Bonferroni's inequalities (Snedecor and Cochran 1989:116). Thus, the level of significance for these tests is 0.05 divided by the total number of tests being made on a set of non-independent behaviors.

RESULTS

The 38 radio-marked kestrels fledged 26 May through 8 August (median = 29 June). Kestrels in a brood fledged on the same day or within 1–3 d of each other.

All tests for differences in behavior by brood size

(average brood size effect) across the 4 wk post-fledging period were not significant (Table 1, BROOD SIZE). Significant decreases through time occurred in perch resting and maintenance behaviors, and significant increases occurred in perch hunting and eating self-captured prey (Table 1, TIME). The rates of decrease in perch resting and maintenance and the rates of increase in perch hunting and eating self-captured prey did not differ significantly between large and small sibling groups (Table 1, TIME \times BROOD SIZE).

No differences in mean pounce rates and percent success were detected between small and large groups (Fig. 1, BROOD SIZE). Significant increases occurred with time in mean pounce rates and percent success (Fig. 1, TIME), but no differences were

Table 2. Percent time (mean percent \pm SE) engaged in social and non-social activity by broods of two and five American Kestrels at weekly intervals after fledging in Iowa.

BEHAVIOR BY SOCIAL ACTIVITY	BROOD SIZE	WEEKS POST-FLEDGING				1-4 P-VALUES ^a		
		1	2	3	4	BROOD SIZE	TIME	\times BROOD SIZE
		MEAN \pm SE	MEAN \pm SE	MEAN \pm SE	MEAN \pm SE			
Perch resting (N)^b	2	(8)	(5)	(5)	(3)	0.118	0.708	0.796
	5	(8)	(8)	(7)	(7)			
Association	2	19.9 \pm 13.6	11.8 \pm 11.8	22.3 \pm 13.8	0.0	0.705	0.680	0.899
	5	23.5 \pm 9.5	38.1 \pm 12.0	32.2 \pm 8.1	23.9 \pm 9.7			
Nonsocial	2	80.1 \pm 13.6	88.2 \pm 11.8	77.7 \pm 13.8	100.0 \pm 0.0	0.633	0.674	0.675
	5	71.3 \pm 11.6	61.1 \pm 12.2	67.4 \pm 8.2	76.1 \pm 9.7			
Undetermined ^c	2	0.0	0.0	0.0	0.0	—	—	—
	5	5.2 \pm 4.1	0.7 \pm 0.7	0.4 \pm 0.4	0.0			
Perch hunting (N)	2		(1)	(5)	(3)	0.662	0.654	0.807
	5		(2)	(7)	(7)			
Association	2	0.0	0.0	12.8 \pm 12.1	13.6 \pm 13.6	0.187	0.427	0.775
	5	0.0	10.1 \pm 10.1	10.6 \pm 11.3	9.0 \pm 7.0			
Social hunting	2	0.0	8.7 \pm 0.0	14.8 \pm 8.4	6.2 \pm 6.2	0.634	0.891	0.891
	5	0.0	38.7 \pm 11.3	42.0 \pm 13.4	22.7 \pm 7.9			
Nonsocial	2	0.0	91.3 \pm 0.0	72.4 \pm 19.2	80.2 \pm 19.8	—	—	—
	5	0.0	51.2 \pm 1.2	47.1 \pm 14.5	68.3 \pm 13.4			
Undetermined	2	0.0	0.0	0.0	0.0	—	—	—
	5	0.0	0.0	0.3 \pm 0.3	0.0			

^a ANOVA for brood size, time and time \times brood size across 4 wk post-fledging (perch resting df = 1, 28; perch hunting df = 1, 9). All tests for nonlinearity, except Perch resting/nonsocial behavior Time ($P < 0.001$), were not significant.

^b Total number of broods of two and five siblings observed.

^c Social status of focal bird could not be determined.

observed between small and large groups in the rates of increase of these hunting activities (Fig. 1, TIME \times BROOD SIZE).

Young American Kestrels fed primarily on insects, which comprised 95% (71/75) and 97% (107/110) of the prey items caught by small and large sibling groups, respectively. At least 16% (28/178) of these insects were grasshoppers (Orthoptera). We were unable to identify the other insects caught. One bird fed on earthworms (Oligochaeta) 16 d after fledging, and three birds captured four small mammals. Two of these mammals were voles (*Microtus* sp.), and the others were not identified.

No differences in social activity were found between brood sizes (Table 2, BROOD SIZE) or in linear trends in social activity over time (Table 2, TIME). Allopreening or beaking exchanges were observed during 12% (10/85) of the observation sessions on small and large sibling groups. These two

social behaviors were observed at least once in two of the small broods and in six of the large broods.

Social hunting occurred during 51% (21/41) of the sessions in which hunting was observed in small and large broods. Social hunting was observed at least once in 50% (4/8) of the small broods and in 75% (6/8) of the large broods. For sessions in which social hunting was observed ($N = 21$), 72% involved siblings only, 14% involved siblings and parents, and 14% involved siblings and unrelated kestrels.

Mean time of dispersal was 23.2 d for small broods ($N = 6$, SE = 1.9) and 26.7 d for large broods ($N = 7$, SE = 2.0). This difference was not significant (ANOVA, $P = 0.299$).

DISCUSSION

All tests for average brood size effects for kestrel behavior, hunting, and social activities were not significant. When trends in behavioral change over time

were detected, no significant differences occurred in the rates of change between small and large broods. Thus, broods of two and five kestrels did not differ in behavior, social, or hunting activity during the 4 wk that broods were observed.

Although we were unable to demonstrate any brood size effects, the power of our statistical tests was low because of small sample sizes. Small sample sizes increase the probability of Type II error (Snedecor and Cochran 1989).

Mortality or loss of the radio signal was high among radiotagged kestrels the first week after fledging, and resulted in 47% (15 to 8) and 33% (12 to 8) decreases in sample sizes for groups of two and five siblings, respectively. This high mortality was unexpected. Only 2 of 26 birds radiomarked in 1988 and 1989 died (Varland 1991). Predation was the largest source of mortality for small and large broods, and accounted for 9 of 14 deaths.

Kestrels wearing radiotransmitters may have been vulnerable to predation. The mean weight of transmitters in this study was 6.2 g, which is 5% of the mean weight of adult male American Kestrels (112 g) and is 4% of the mean weight of adult females (141 g; Cade 1982). These percentages are within the 3–5% of body weight limits recommended for transmitters used on birds (Hegdal and Colvin 1986). While we observed no obvious behavioral differences between fledglings wearing transmitters and those that were not wearing them, the study was not designed to make a quantitative comparison between marked and unmarked groups.

Starvation was not an important cause of mortality (1 of 14 deaths), but may have been significant later in the first year of life. Because of movement of young away from their natal areas, we were unable to observe any kestrel longer than 39 d after fledging. Starvation was the most important cause of mortality after independence from their parents among juvenile Yellow-eyed Juncos (*Junco phaeonotus*; Sullivan 1989) and Tawny Owls (*Strix aluco*; Hirons et al. 1979).

Young kestrels presumably learn hunting skills during the first 4–6 wk after fledging. Imitative social hunting during this period may provide an adaptive advantage to individuals later in the juvenile period, if there is sufficient selection for learned efficiency in hunting. Mean hunting success from perches in this study and in earlier research (Varland et al. 1991) did not exceed 55%. This is a substantially lower success rate than previously reported for

older kestrels hunting invertebrates (Collopy 1973, Smallwood 1987, Toland 1987).

This study has left open to question whether imitative social hunting by American Kestrels after fledging influences hunting efficiency. If learning does occur during the development of hunting, perhaps siblings learn more from observing their parents than they learn from each other. Our study was not designed to test this idea. Further research is needed to document whether social hunting influences hunting efficiency in American Kestrels.

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DISTRIBUTION AND COLOR VARIATION OF GYRFALCONS IN RUSSIA

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ABSTRACT.—Gyrfalcon (*Falco rusticolus*) museum specimens in Moscow (73) and St. Petersburg (132) were divided into four color classes (gray, light gray, white gray, and white) and four longitudinal belts representing major physiographic regions of northern Russia. Gray variants predominated in the west and central regions. White birds were most common in extreme eastern Siberia, but were occasionally found even west of the Ural Mountains. Frequencies were as follows: European Russia 4% white, 50% gray (the remainder were intermediates); western Siberia 0% white, 58% gray; central Siberia 15% white, 42% gray; and eastern Siberia 47% white, 33% gray. Remarkably, in the easternmost subregion, white birds predominated even near the southernmost extension.

Because the northernmost portions of the species' range in continental Russia are in central Siberia where white variants were rare, we propose that a better predictor of the white variant is longitude, not latitude. White birds were most frequent at the eastern reaches of both the Palearctic and Nearctic. The best environmental correlates of this distribution pattern may be the southward bending thermal isoclines proceeding eastward toward Greenland or Kamchatka, where both land masses are bathed by cold oceanic currents of Arctic origin. By contrast, the western reaches of both land masses are bathed by warm currents. In these western reaches, Gyrfalcon summer distribution is displaced northward and dark variants predominate.

The breeding range of the Gyrfalcon, determined by mapping the locations of the specimens we examined, differs little from the range proposed in 1951.

Distribución y variación del color en el Gerifalte en Rusia

EXTRACTO.—Espécimens de Gerifalte (*Falco rusticolus*), existentes en museos de Moscú (73) y San Petersburgo (132), fueron separados en cuatro clases de colores (gris, gris claro, blanco grisáceo y blanco) dentro de cada una de las cuatro regiones longitudinales que representan las mayores regiones fisiográficas del norte de Rusia. Las variantes grises predominan en las regiones del oeste y del centro. Las aves blancas son más comunes en el extremo este de Siberia, y hasta son ocasionalmente encontradas al oeste de los Montes Urales. Las frecuencias son las siguientes: Rusia europea 4% blanco, 50% gris (el resto estaba en el intermedio); Siberia occidental 0% blanco, 58% gris; Siberia central 15% blanco, 42% gris; y Siberia oriental 47% blanco, 33% gris. Es de notar que aves blancas predominan aun cerca de la extensión sur de la subregión extremo-oriental.

Las porciones del extremo norte de la región de Rusia continental, donde se halla esta especie, están en Siberia central donde las variantes blancas son raras. Por esto proponemos que un mejor pronosticador de la variante blanca es la longitud y no la latitud. Las aves blancas son más frecuentes en los extremos orientales tanto del Paleártico como del Neártico. El más importante factor de este ambiente, que correlaciona con esta tendencia de distribución, es el isoclinio termal que se curva hacia el sur y que continúa hacia el este, en dirección de las regiones de Groelandia o Kamchatka que son bañadas por corrientes oceánicas frías de origen ártico. En contraste, el oeste de estas dos regiones es bañado por corrientes cálidas. En estas zonas occidentales, la distribución de verano del *F. rusticolus* se desplaza hacia el norte; y predominan las variantes oscuras.

El área de reproducción de este halcón, basada en los sitios donde fueron colectados los espécimenes de museo, no es muy diferente de la propuesta en 1951.

[Traducción de Eudoxio Paredes-Ruiz]

In the four decades since publication of Dementiev's (1951) monograph on the Gyrfalcon (*Falco rusticolus*), little new information has been published in English on this species for the former Soviet Union (comprising nearly 50% of the species' breeding range). Dementiev's (1951) southern limit of breeding is well substantiated by museum specimens, but did not loop south to include the middle Ural Mountains where he (Dementiev 1960) reported that Gyrfalcons bred a century earlier as far south as the Chusovaya, Ufa and Byelaya Rivers (see Fig. 1).

Recent decades have seen a trend in the published literature toward simplifying (i.e., eliminating undulations) and compressing Dementiev's (1951) breeding range without offering supporting data (e.g., Cade 1982, Flint et al. 1984). These changes, if correct, would signal population declines and/or abandonment of formerly occupied range. The boundary we report is little changed from Dementiev's 1951 map, therefore we affirm the accuracy of his map and recommend its continued use until more information is obtained.

Dementiev (1951, 1960) noted the general trend for Gyrfalcons to be lighter in color and larger proceeding eastward across Eurasia. Portenko (1972) also noted that the white variant predominates on the Chukchi Peninsula. We provide frequencies of color variants for the breadth of Russia based on examination of 205 specimens (91 adult and 114 juveniles) in the two primary bird collections in Russia, the University of Moscow Zoological Museum (UMZM) and the Zoological Institute of the Academic Sciences (ZIAS) in St. Petersburg. In discussing color variation, we amplify Vaurie's (1961), Cade's (1982), and Palmer's (1988) observations that Gyrfalcon plumage is infinitely variable along a continuum from the whitest individuals to dark gray or "black" birds. To recognize color phases or, more precisely, color morphs (e.g., white, gray, brown, black) is misleading. It is instructive, however, to report regional trends in the occurrence of light, dark, and intermediate birds.

METHODS

This study is based primarily on examination of the Gyrfalcon skins, specimen tags and catalogues at the UMZM (73 specimens) and the ZIAS (132 specimens). Great effort was expended to translate old Russian script

for dates (from the Julian to Gregorian calendars) and locations (from pre- to post-revolutionary regions). Specimens that lacked sufficient data were excluded from our analysis as were the few birds with spurious data. For example, we excluded ZIAS No. 75403 (which by color and size is a large second-year female Gyrfalcon) because its original label identified it as a male Peregrine Falcon (*F. peregrinus*); its collection date and locale are also better matches for a breeding peregrine.

This study required that we deal with the difficulties presented by the possible taxonomic affinities of the Gyrfalcon, Saker (*F. cherrug*), and Altay (or Altai) Falcon (*F. rusticolus/cherrug altaicus*). Our response was to include only birds that were clearly Gyrfalcons of the non-Altay Falcon type, judging either by collection location and date, or by plumage. This separation was difficult for only a few immatures, those which had the spotted tail pattern thought typical of Sakers. As Cade (1982) indicated, some Sakers also have Gyrfalcon-like barred tails.

We included only one specimen (ZIAS No. 75497) that had previously been treated as an Altay Falcon (cotype of *Gennaia lorenzi*: considered synonymous with *F. r./c. altaicus*, Sushkin 1938, Vaurie 1961). This specimen was a large, gray female Gyrfalcon and lacked the brown dorsal background color that characterizes even the most Gyrfalcon-like of the supposed Altay types. Its location, near the southern end of the Ural Mountains and over 1000 km from the mountains of Central Asia where the Altay Falcon reportedly occurs (Dementiev and Gladkov 1951), and collection date (October or November 1900) are a good match for a migrating Gyrfalcon.

Recognizing that color varies along a continuum (Vaurie 1961), we nonetheless, for comparison purposes, grouped all the specimens into eight age/color classes as follows: white variants (adult and juvenile) were birds with white as a dorsal background color; white gray birds were adults with dorsal dark barring approaching that of gray adults but with very little gray in an otherwise white dorsal background; white brown birds, the corresponding juvenile variant, were pale brown dorsally with light tips and edges and were lightly streaked with brown ventrally on a pale cream background color; light gray birds (and light brown juveniles) had the heavily barred dorsal pattern of normal gray adults (or brown mantle if juveniles) but their dorsal background color, and often the hue of their light and dark bars, was much lighter than the gray variant (or brown variant if juvenile); gray (or brown if juvenile) variants differed from light gray (or light brown) birds in having darker gray (or brown) pigmentation dorsally. Gray adults often had a light gray wash ventrally, especially on tibias and lower belly, while juveniles had darker ventral streaking and a darker buff wash than other variants. Birds in mixed plumage (molting) provided evidence that the four juvenile classes molt into corresponding adult classes (e.g., white brown juveniles become white gray adults). Examples of adults (and two juveniles) representing most of our light and dark variants are illustrated in Weick's (1980) Plate 39. Juveniles, although often showing a grayish bloom

or even indistinct grayish bars on brown plumage, were never generally gray as Palmer (1988:383, 387) repeatedly states.

Because Gyrfalcons from narrow longitudinal zones probably mix somewhat on the wintering grounds and could thereby confuse our interpretation of regional trends, we analyzed a data subset consisting entirely of falcons collected May through August. Because the number of summer specimens in each longitudinal belt was too small to make all of the comparisons we sought, we increased our sample size by: 1) translating all juvenile plumaged birds into their corresponding adult category, 2) pooling summer and non-summer collections, and 3) pooling 15 longitudinal zones (of 10 degrees each) into four major longitudinal regions that reflect important physiographic regions of Russia (see Fig. 1). These manipulations provided for 70, 60, 33, and 42 birds respectively in the west to east longitudinal regions.

To further minimize the problem of having birds from one longitudinal region in summer collected in a neighboring region in winter, we chose natural physiographic boundaries between regions. The Ural Mountains divide the first two regions, European Russia (30° – 60° E) and western Siberia (60° – 90° E), and probably serve as an effective barrier to prevent mixing of wintering birds. The latter region, western Siberia, constitutes the lowlands between the Ob and Yenisey Rivers which are unlike the third region, the topographically complex Central Siberian Uplands (90° – 150° E). The eastern Siberian region (150° E– 169° W) is not well demarcated from the neighboring region to the west. There is, however, a somewhat artificial separation occasioned by the complete lack of specimens for a 10 degree wide boundary (140° – 150° E) between the two regions.

We used two methods of contingency table analysis to compare the proportions of each color variant among the four regions. Specimens were assumed to be independent. We know of only one exception to this rule (i.e., two birds were presumed siblings). Because few summer specimens were available, we used Fisher's exact test (Agresti 1990: 59–64) to test the hypothesis that color variants were equally distributed among the regions in summer. For the entire data set, we used log-linear models (Agresti 1990:130–134) to test these same hypotheses. We also used 1 df contrasts for specific tests associated with departures from the hypothesis of equal proportions of color variants among the four regions.

RESULTS AND DISCUSSION

Recent works (e.g., Cade 1982) show summer distribution significantly restricted from that presented by Dementiev (1951). Even publications by Russian authors (Flint and Potapov 1984, Flint et al. 1984), with access to a dozen or so post-1951 Russian language publications on the Gyrfalcon, have also eliminated the irregularities in Dementiev's (1951) line, even though Dementiev's major southward extension in central Siberia was made to accommodate two recently fledged young (ZIAS Nos.

127705 and 127706) collected in July 1918 along the Lower Tunguska River. The summer limit we present (Fig. 1) follows Dementiev's (1951) boundary line and shows the historic southern limit of montane breeding in the central Ural Mountains (Dementiev 1960). Our map also adds one minor southward extension in central Siberia to include a juvenile (ZIAS No. 168211) collected on 16 July 1956 in the upper drainage of the Yana River.

In Figure 1, we also plot a juvenile (ZIAS No. 75428) collected 9 August 1937 in western Siberia near the town of Surgut (on the Ob River) about 450 km south of Dementiev's (1951) line. An adult female collected in June 1904 in Irkutsk Province (central Siberia), most of which is well south of Dementiev's (1951) line, could not be mapped because its collection location information was too general. One or both of these specimens would extend the summer range. Juveniles, however, begin wandering even in July (Cramp et al. 1980) and Dementiev (1951) included neither record, so we omit them also. We suspect, however, that a thorough search of the areas immediately south of our boundary line would, especially in favorable prey years, yield many summer and breeding records.

Our work did not concentrate on winter records. We note, however, that Dementiev's (1951) demarcation of the southern limit of winter distribution of Gyrfalcons extends much further south than illustrated by either Cade (1982) or Cramp et al. (1980). Perhaps the best explanation of this discrepancy is that Cade describes his line as representing the southern limit of the "usual winter migration" range without offering evidence, whereas Dementiev's (1951) line includes all records. Cramp et al. (1980) may have been influenced by authors who reported marked Gyrfalcon declines in western Europe during this century. The only author they cite for Russia, however, presented no information on Gyrfalcon populations (Galushin 1977). There is a sizable corps of field ornithologists and many active field stations in Russia. Until the observational records from these sources are collated, we must rely on the specimen records presented in Dementiev's (1951) monograph.

The distribution of color variants in Russia was discussed briefly by Vaurie (1961). He reported that white birds constitute 50% of the population east of the Lena River (Fig. 1), with white birds found as far west as the Pechora River (just west of the Ural Mountains) and composing 4% of the population

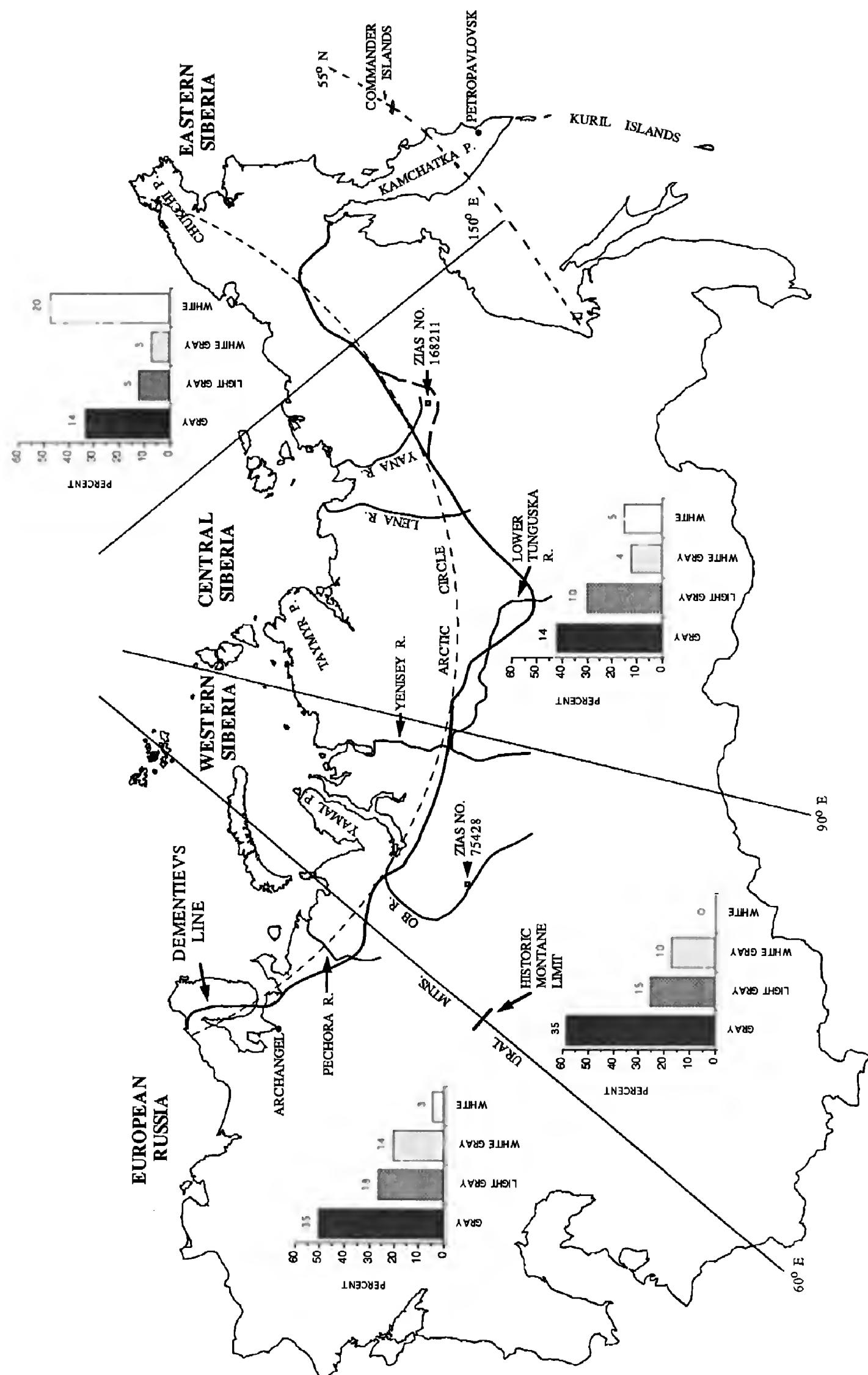


Figure 1. Variation in plumage color and limits of the breeding range of Gyrfalcons in Russia.

Table 1. Number of Gyrfalcon specimens of four color classes collected in four regions of Russia during summer (May–August).

COLOR VARIANT	REGION			
	EURO-PEAN RUSSIA	WESTERN SIBERIA	CENTRAL SIBERIA	EASTERN SIBERIA
Gray	5	4	6	2
Light gray	2	1	4	1
White gray	0	1	0	1
White	1	0	0	4
Total	8	6	10	8

between the Lena and Pechora Rivers. We examined two white adults and one white juvenile from European Russia: the furthest west was an adult (ZIAS 75352) collected in November in the Archangel region. White birds found in winter in European Russia may not represent the continental breeding population, but may be from Spitzbergen or other northern islands. Vaurie (1961) noted that the “black” Gyrfalcon, numerically important only in Labrador in eastern North America, is absent from Eurasia. However, he reported that one bird he examined from Europe was virtually as dark as “black” Gyrfalcons from eastern North America. Further, Dementiev (1960) reported 3 black Gyrfalcons among 99 birds held by a Russian Czar. We did not encounter any dark specimens from European Russia.

It bears mention that Vaurie’s (1961) comments and the distributional patterns we report, do not include records for the Altay Falcon (Central Asia) for which many individuals, both juvenile and adult, closely resemble juvenile “black” Gyrfalcons from Labrador. Dementiev (1951:26) had earlier commented on the remarkable “parallel coloration” of the darkest Altay Falcons and the “melanistic variant of the North American Gyrfalcon.”

Using the summer specimens alone (Table 1), no significant difference was found ($FI = 11.76, P = 0.119$) in the proportions of color classes when all four regions were compared. However, when the specimens from the three westernmost regions, which had no indication of different patterns of color variation ($FI = 5.078, P = 0.635$), were combined and compared with those from eastern Siberia, there was a statistically significant difference ($FI = 9.507, P = 0.011$). Eastern Siberia had a higher proportion

Table 2. Number (and proportion) of Gyrfalcon specimens of four color classes collected in four regions of Russia.

COLOR VARIANT	REGION			
	EURO-PEAN RUSSIA	WESTERN SIBERIA	CENTRAL SIBERIA	EASTERN SIBERIA
Gray	35 (0.50)	35 (0.58)	14 (0.42)	14 (0.33)
Light gray	18 (0.26)	15 (0.25)	10 (0.30)	5 (0.12)
White gray	14 (0.20)	10 (0.17)	4 (0.12)	3 (0.07)
White	3 (0.04)	0 (0.00)	5 (0.15)	20 (0.47)
Total	70	60	33	42

of white birds and a lower proportion of gray birds than the other regions combined (Table 1).

When we pooled data for the entire year, the most apparent regional trend (Table 2) was the prevalence of white birds in eastern Siberia (47%). Only 33% of the birds in this region were of the gray variant and 67% were lighter than the normal gray type. Proceeding west, the proportion of light gray to white types drops to 57% in central Siberia, then 42% for western Siberia, but rises again to 50% for European Russia even though fully white birds make up only 4% of the latter population. The absence of white specimens for western Siberia is surprising because Pleske (1928) reported white birds for the region, and white nestlings taken from the Yamal Peninsula are now in the propagation project at the Oka State Nature Reserve in Ryazan Province.

The differences in color composition among regions were statistically significant ($\chi^2 = 54.91, df = 9, P < 0.001$). Based on this test, 1 df contrasts yielded the following results. As with the summer specimens, the eastern Siberia region had the highest proportion of white falcons and, conversely, the lowest proportion of the other three variants ($\chi^2 = 41.51, P < 0.001$). The sample from central Siberia also had a higher proportion of white birds and a lower proportion of the other variants than either of the two regions to the west ($\chi^2 = 7.21, P = 0.007$), but not as large a proportion of white birds as eastern Siberia ($\chi^2 = 9.28, P = 0.002$; Table 2).

The data for Russia as a whole seem to contradict Brown and Amadon’s (1968:844) generalization that the proportion of white Gyrfalcons increases with increasing latitude. In continental Russia, the northernmost regions occupied by the Gyrfalcon are not

in eastern Siberia where white forms predominate, but around the Taymyr Peninsula in western and central Siberia where white forms are rare. Rather, the strong trend for Russia is for white forms to predominate in the easternmost and perhaps the southernmost extensions of the species' range, the Chukchi and Kamchatka Peninsulas. From Kamchatka, 5 of 17 specimens (29%) were white and 9 of 17 (53%) were of the three lighter variants; for the nearby Commander Islands, 6 of 8 specimens were white. Unfortunately few summer specimens are available from these areas, so little can be said about frequencies of the four variants as breeders, but Stejneger (1885) reports that the white, not the gray, variant is the only known breeding Gyrfalcon on Bering Island, largest of the Commander Islands. Both of the summer adults from Bering Island collected by Stejneger, and now housed at the U.S. National Museum, are white.

Kamchatka and the Commander Islands are also of interest because they extend to and beyond 55°N, the latitude Cade (1982) proposes as the general southern limit of Gyrfalcon breeding. The basis for including all of Kamchatka is perhaps the statement by Dementiev and Gladkov (1951) that the species summers near Petropavlovsk, near the southern tip. Dementiev and Gladkov (1951), however, dispute Yamashina's (1931) claim that the species occasionally breeds further south than Kamchatka, on the middle Kuril Islands.

Kamchatka is mapped within the breeding range by all authors, even Flint et al. (1984), who state, however, that no eyrie has yet been found there. More recently, Lobkov (1986) reported that Gyrfalcons breed regularly on northern Kamchatka. Observations of pairs in summer further south indicate that Gyrfalcons may breed on the east coast as far south as 100–200 km north of Petropavlovsk. Lobkov (1986), however, provides no records for summer pairs on the western slope of Kamchatka, so perhaps the summer range should be adjusted eastward.

The occurrence and even breeding of white birds on the Commander Islands at or beyond Cade's (1982) proposed southern breeding limit is remarkable. Even in North America, white Gyrfalcons, although much more prevalent in northern Greenland and adjacent islands (Salomonsen 1950), are found with fair regularity in Ungava near the southern extremity of the species' North American range (Palmer 1988).

We propose that the primary trend in color variation for Eurasia and probably for the Nearctic (Neoarctic) is for the white variant to become increasingly prevalent proceeding eastward across the two land masses. Prevalence of the white form correlates better with longitude than latitude. A similar trend is also reported for Rough-legged Hawks (*Buteo lagopus*) in the Palearctic (Dementiev and Gladkov 1951:307).

We account for this light in the east and dark in the west phenomenon by examining thermal isoclines and oceanic currents for both land masses. Cleveland (1986) shows that the eastern areas of both regions are colder at comparable latitudes than the central or western regions. This colder east and warmer west pattern is probably best explained by the presence of north flowing, warm oceanic currents along the western reaches of these primary landmasses (the Alaska and Bering Currents for North America, and the Norway Current, the northeast extension of the Gulf Stream, for Scandinavia), and south flowing cold currents bathing the eastern extensions (the east Greenland and Labrador currents for the Nearctic and the Anadyr and Oya currents for Siberia).

Another way to look at the influence of temperature is to compare mean annual temperatures (Cleveland 1986) at the southernmost extensions of Gyrfalcon distribution. Although Labrador and Kamchatka (at the eastern reaches) are far south of Norway and the Alaskan Peninsula (the western reaches), all four areas lie in the same thermal zone (−1° to +4° C mean annual temperature).

If, as suggested by a gross inspection of Gyrfalcon distribution worldwide, ocean current temperatures are of primary importance in determining Gyrfalcon breeding and prevalence of the white variant, then, within broad limits, nesting populations on small islands should reflect this influence even more than populations on large land masses. This means that island-nesting Gyrfalcons should be found further south off the eastern reaches of the two primary land masses and further north off the western reaches. The white form should also be more common on islands than on the mainland at comparable latitudes. The presence of only white breeders on the Commander Islands supports this hypothesis and gives credence to Yamashina's (1931) statement that Gyrfalcons occasionally breed in the middle Kuril Islands (ca. 47°N).

Further, if the ocean temperature theory as stated above is generally correct, local exceptions to this rule should be explicable on the basis of local ocean temperatures. For example, complete absence of white breeders on Iceland, at 65°N and only 300 km from Greenland, seems to violate the general ocean-thermocline rule. On closer inspection, however, we note that Iceland is bathed on all sides by a northward extending tongue of the warm North Atlantic Current (Cleveland 1986) and as a result is better suited for gray birds. Salomonsen (1950:447) reported that for the eastern Nearctic the prevalence of white birds increases with decreasing temperature. A detailed island-by-island comparison of color variant ratios with isotherms for air and water is needed, and may be possible using existing collections worldwide, but is beyond the scope of this paper. We believe that such a treatment will show that midsummer water and/or air temperatures are the best predictors of Gyrfalcon presence and color prevalence worldwide.

To better understand the importance of color polymorphism in the Gyrfalcon, data on summer and winter food habits are needed. These data will be most convincing if dissimilar diets can be demonstrated for white and dark variants in their zones of sympatry.

The ecological significance of various color morphs within a population has been demonstrated for perhaps only one raptor. In the Red-tailed Hawk (*B. jamaicensis*) different color morphs perch, and presumably forage, differently (Preston 1980). Rohwer and Paulson (1987) also discuss the advantages of a predator species having more than one morph within the same population. In addition, the Parasitic Jaeger (*Stercorarius parasiticus*) exhibits a light morph more commonly in the northern parts of its range and a dark morph comprising 70–80% of birds in the southern limits of the species' breeding range in Great Britain (Berry and Davis 1970). These authors report some strong color morph correlates in timing of breeding and prey selection.

The presence of very dark birds in Labrador can perhaps be best explained on the basis that these dark birds are descendants of a population adapted to a warmer or more humid southern climate during a time when a deme of dark falcons was separated by Pleistocene ice from more northerly refugia where white and gray populations persisted (Palmer 1988; see Temple 1972 for a similar explanation of the

evolution of North American races of the Merlin, *F. columbarius*). In recent times, these demes met and to some degree mixed. Today white and black birds occur in both Labrador and Greenland. We propose that the modern day persistence of strong regional trends in color prevalence in the eastern Nearctic is due in part to two factors that impede panmixia. First, the Labrador Sea probably acts as a barrier to gene flow, and second, the light and dark variants probably have a selective advantage where they are most common and are therefore favored.

In summary, extant specimens in the two museums, ZIAS and UMZM, substantiate Dementiev's (1951) summer distribution map. The data for Russia also prompted us to re-evaluate interpretations of environmental correlates of Gyrfalcon distribution and color variation worldwide. It appears that latitude is not the best predictor of Gyrfalcon presence or color. Rather, climate, as reflected by isotherms and as related to the temperature of oceanic currents, better correlates with Gyrfalcon breeding distribution and the prevalence of each color variant. Our conclusion, that climate is more important than latitude, is supported not only by the presence of a higher proportion of white birds at the eastern reaches of both the Nearctic and Palearctic, but also by the extreme southward extensions (south of 55°N) of Gyrfalcon breeding distribution at the eastern reaches in Labrador and Kamchatka and, conversely, northward contractions at the western reaches of both the Palearctic and Nearctic.

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BARN OWL PREY IN SOUTHERN LA PAMPA, ARGENTINA

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The Barn Owl (*Tyto alba*) is widespread in Argentina, ranging from subtropical forests in Salta and Misiones to arid shrub-steppe habitat in Patagonia. In La Pampa it inhabits Caldén (*Prosopis caldenia*) forests, Monte Desert shrublands and agricultural land of the eastern part of the province where suitable roosting and nesting sites are available.

Previous analyses of Barn Owl pellets in La Pampa have been conducted (Justo and De Santis 1982, De Santis et al. 1983, 1988, Montalvo et al. 1984, Massoia and Vetrano 1988, Tiranti 1988). However, more information would be needed to evaluate the variation in prey from different sites. I present the results of a prey analysis for two pellet collections from southeastern La Pampa.

STUDY AREAS AND METHODS

On 20 November 1986, 96 intact pellets and pellet debris, which yielded 440 prey items, were obtained in a 6 m deep hand-dug well in the proximity of human dwellings, in Estancia Luan Cura Hué (38°05'S 64°33'W), 36 km north of Cuchillo Có, Lihuel Calel region. Two barn owls occupied this site.

A second collection of 110 whole pellets and pellet fragments which rendered 257 prey items, was pooled from three roosting sites near Cuchillo Có (38°20'S 64°40'W) Lihuel Calel region, between 5 and 7 October 1988. One site consisted of a Caldén tree, another was an unused water tank in a windmill, and a third a steep mesa ledge. No owls were observed at these sites but their presence was confirmed by molted feathers. In both collections the period of pellet accumulation must have been at least some months.

All the study areas are characterized by a mosaic of open Caldén forests, mixed shrublands with *Larrea divaricata* and *Condalia microphylla*, and grasslands with *Elionurus muticus* and *Stipa* spp. (Cano et al. 1980). In a broader sense they belong to the ecotone between the Espinal and Monte biomes, that include xerophytic forests and shrublands respectively (Cabrera 1976).

Skulls and skull fragments of mammals and birds, a head of a lizard and chitinous fragments of insects were recovered from the pellets examined. These remains were identified by comparing them with museum specimens collected in various localities and times in La Pampa. Because of the extreme difficulty, no attempt was made to

differentiate between the two species of *Calomys* (*C. musculinus* and *C. laucha*) that inhabit La Pampa, but most individuals are likely *C. musculinus*. *Calomys laucha* has been found in only two localities in this province (Justo and Montalvo 1981, unpubl.). The species of *Ctenomys* detected in the diet probably represents *C. azarae*. Of the birds recovered, only *Molothrus* sp. could be identified (from Cuchillo Có).

Prey biomass was computed only for mammals using data from adult specimens collected in various localities and times in La Pampa, except for *Reithrodont auritus*, the weight of which was taken from Pearson (1988). Thus, mean weight and range of prey species are: *Akodon azarae* 22 g (range 14-35, $N = 21$), *Akodon molinae* 38 g (range 20-65, $N = 51$), *Calomys musculinus* 16 g (range 9-37, $N = 27$), *Ctenomys azarae* 153 g (range 105-250, $N = 18$), *Eligmodontia typus* 17 g (range 12-24, $N = 30$), *Galea musteloides* about 200 g, *Graomys griseoflavus* 61 g (range 44-90, $N = 15$), *Oligoryzomys flavescens* 22 g (range 13-35, $N = 10$), *Thylamys pusilla* 23 g (range 15-30, $N = 6$), *Eptesicus furinalis* about 12 g and *Reithrodont auritus* about 74 g.

Food Niche Breadth values were calculated as in Martí (1988), categorizing mammals by genera; birds, lizards and insects (including other invertebrates) by class. For comparison, some sites of La Pampa were selected from the literature and niche breadth was calculated as indicated.

RESULTS AND DISCUSSION

As has been previously observed (Justo and De Santis 1982, De Santis et al. 1983, 1988, Massoia and Vetrano 1988, Tiranti 1988), the Barn Owls studied in La Pampa preyed largely on cricetid rodents. Only in one instance (Montalvo et al. 1984) were birds important. The prey species most frequently taken in this study in Estancia Luan Cura Hué included nearly equal proportions of *A. azarae*, *Calomys* sp. and *E. typus*. Together they represented 60.9% of prey items. In the Cuchillo Có collection, *Calomys* sp. was prevalent (52.1%), followed by *E. typus* (25.7%, Table 1). *Akodon azarae* and *Calomys musculinus* are known to occupy agroecosystems at different stages of succession (fallow fields and crops; Kravetz et al. 1986). *E. typus* has been considered an arid-adapted rodent of the Monte Desert (Mares 1977), that favors low cover or open areas (Ojeda 1989). This agrees with previous descriptions of

Table 1. Barn-Owl prey derived from pellets collected at Luan Cura Hué ($N = 440$) and Cuchillo Có ($N = 257$) in southern La Pampa, Argentina. The combined niche breadth for a total of 697 prey items was 4.75.

SPECIES	LUAN CURA HUÉ			CUCHILLO CÓ		
	N	%	% BIOMASS FOR MAMMALS	N	%	% BIOMASS FOR MAMMALS
			FOR MAMMALS			FOR MAMMALS
Rodents						
Azara's Grass Mouse (<i>Akodon azarae</i>)	99	22.5	16.1	5	1.9	1.8
Molina's Grass Mouse (<i>Akodon molinae</i>)	47	10.7	13.3	6	2.3	3.8
Vesper Mouse (<i>Calomys</i> sp.)	93	21.1	11.1	134	52.1	35.6
Tuco-tuco (<i>Ctenomys</i> sp.)	23	5.2	26.4			
Silky Desert Mouse (<i>Eligmodontia typus</i>)	76	17.3	9.6	66	25.7	18.5
Yellow-toothed Cavy (<i>Galea musteloides</i>)	1	0.2	1.5			
White-bellied Rat (<i>Graomys griseoflavus</i>)	11	2.5	5.0	26	10.1	26.5
Rice Rat (<i>Oligoryzomys flavescens</i>)	18	4.1	3.0			
Rabbit Rat (<i>Reithrodont auritus</i>)	11	2.5	6.0	8	3.1	9.8
Bats						
Brown Bat (<i>Eptesicus furinalis</i>)				1	0.4	0.2
Marsupials						
Mouse Opossum (<i>Thylamys pusilla</i>)	47	10.7	8.0	10	3.9	3.8
Passerine birds						
	11	2.5		1	0.4	
Reptiles						
Green lizard (<i>Teius oculatus</i>)	1	0.2				
Insects						
	2	0.5				

the Barn Owl as an essentially open country predator (Colvin and McLean 1986). Considering biomass, *Ctenomys* sp. becomes important in the Luan Cura Hué collection and *Calomys* sp., *E. typus* and *G. griseoflavus* in the Cuchillo Có collection.

Niche breadth was used to evaluate the use of food resources. The value may vary from unity, if only one prey category is consumed, to a maximum when all resources are used equally (Petraitis 1979, Marti 1988). In this study, most of the niche breadth values (Table 2) are quite similar to those given by Marti (1988) for Barn Owl diets throughout the world. Thus, the extent of variation observed by this author can be reflected at a local scale.

I was unable to compare local abundance of small mammals, as revealed by trapping, with pellet remains. However, at a site about 50 km east of Cuchillo Có, in an ecologically similar habitat (*Larrea divaricata* shrubland), I captured 44 small mammals during 270 trapnights in July 1986. These included 35 (80%) *A. molinae*, 5 (11%) *C. musculinus*, 2 (5%) *Oligoryzomys longicaudatus*, 1 (2%) *G. musteloides* and 1 (2%) *T. pusilla*. At this site, in a small sample of Barn Owl pellets containing 42 individual prey remains, *A. molinae* made up 45% ($N = 19$), of the total prey, followed by *Calomys* sp. 36% ($N = 15$), *G. griseoflavus* 14% ($N = 6$), *O. longicaudatus* 2% ($N = 1$) and *T. pusilla* 2% ($N = 1$). Although scant, this information confirms

what has been widely observed, that *Tyto alba* preys essentially on whatever small mammals are available in a given area (Marti 1988, Torres Mura and Contreras 1989), constrained by prey size, prey abundance, habitat and behavior of the owls (Colvin and McLean 1986).

Variation in prey has been observed (Table 2). In general, there is a tendency for the smaller species (*Calomys* sp., *Eligmodontia typus*, *Akodon azarae*) to be more frequently consumed by Barn Owls in La Pampa, than the larger species (Table 2). Although small, the Rice Rat *Oligoryzomys flavescens* appeared in low percentages in the Barn Owls studied (Table 1). This is probably because this rodent is restricted to more mesic conditions, generally in proximity of water. The Rice Rat inhabits areas that the owls may not exploit, such as the dense semi-halophytic shrublands of *Cyclolepis genistoides*. Nevertheless, two species of this genus, taken together, are prevalent in barn-owl diets in other parts of Argentina. For example, these rodents make up 30% of the diet in Ibicuy, Entre Ríos Province (Massoia 1983), and 51% and 48% for Arroyo Yabebirí and Bonpland, in Misiones Province, respectively (Massoia et al. 1989a, 1989b). Other species of mammals that occasionally fall prey to the Barn Owl in La Pampa besides those found in this study, are the Small Cavy *Microcavia australis*, the Free-tailed Bat *Tadarida brasiliensis* (Montalvo et al. 1984), the Red Vizcacha Rat *Tym-*

Table 2. A regional comparison of small mammal prey used by Barn Owls in La Pampa, Argentina.

LOCALITY	DOMINANT PREY	PERCENT			SOURCE
		OF DOMINANT PREY	FOOD NICHE BREADTH	PREY NUMBER	
Alta Italia	<i>Calomys</i> sp.	85	1.37	347	Massoia and Vetrano 1988
La Elenita	<i>Calomys</i> sp.	79	1.54	165	Tiranti 1988
Cuchillo Có	<i>Calomys</i> sp.	52	2.84	257	This study
Luan Toro ^a	<i>Calomys</i> sp.	50	3.01	784	^b De Santis et al. 1988
Bajo Giuliani	<i>Calomys</i> sp.	42	3.61	272	De Santis et al. 1983
Santa Rosa ^a	<i>Calomys</i> sp.	42	3.62	273	^b De Santis et al. 1988
Puelén ^a	<i>Eligmodontia typus</i>	38	3.66	362	^b De Santis et al. 1988
Chacharramendi ^a	<i>Calomys</i> sp.	40	3.95	394	^b De Santis et al. 1988
Casa de Piedra	<i>Eligmodontia typus</i>	30	4.39	440	^c Montalvo et al. 1984
Luan Cura Hué	<i>Akodon azarae</i>	23	4.94	440	This study
Los Ranqueles	<i>Eligmodontia typus</i>	24	5.19	217	Tiranti 1988

^a Samples from different localities were pooled.

^b Only mammals were considered in this study; if other prey were present, niche breadth might be slightly underestimated.

^c Birds were prevalent in this study.

panoctomys barrerae, a rare octodontid (Justo et al. 1985) and the House Mouse *Mus domesticus* (De Santis et al. 1983).

Geographic variation in diet of owls has been attributed to variations in habitat (Campbell et al. 1987) and differences in patchiness of vegetation (Marti 1988). In agricultural areas and grasslands of La Pampa, for example, prey is comprised almost entirely of *Calomys* sp. (Table 2: Alta Italia). In more heterogeneous and less disturbed habitats, the variety of prey is increased (Table 1). Similar observations of variation in Barn Owl diet between agricultural land and natural areas have been made. In Idaho farmland, for example, voles (*Microtus* spp.) were predominant but the percentages decreased as the area dedicated to irrigated farmland diminished and prey species of the surrounding desert began to appear in higher percentages in the Barn Owl's diet (Marti 1988).

Another factor that may influence variation in diet is differences in vulnerability to predation, as recent experiments have demonstrated for North American species (Kotler et al. 1988, Derting and Cranford 1989).

In general, bats and lizards made up a small portion of prey. *Eptesicus furinalis* and *Teius oculatus* were, to my knowledge, recorded for the first time as prey of the Barn Owl in Argentina. The insect remains were tettigoniid grasshoppers.

RESUMEN.—Se analizó un total de 697 presas provenientes de regurgitados de la Lechuza de los Campanarios (*Tyto alba*) de dos localidades del sur de La Pampa, Argentina. Los roedores cricétidos *Calomys* sp. y *Akodon azarae* fueron las especies de presas predominantes en la dieta. Con fines comparativos se presentan datos de la variación de la amplitud del nicho trófico en varios sitios de la provincia.

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SPRING MIGRATION OF HONEY BUZZARDS (*PERNIS APIVORUS*) AT THE STRAITS OF MESSINA IN RELATION TO ATMOSPHERIC CONDITIONS

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The Honey Buzzard (*Pernis apivorus*) is a summer resident in Europe. It winters in west-central equatorial Africa, although some individuals have been observed in southern and eastern Africa (Vaurie 1965, Glutz et al. 1971, Moreau 1972, Cramp and Simmons 1980). The Honey Buzzard follows three migration routes across the Mediterranean Sea: the Straits of Gibraltar, the Channel of Sicily and the Bosphorus (Cramp and Simmons 1980, Porter and Beaman 1985). At the Straits of Gibraltar, most buzzards migrate north in spring, from the end of April to the end of May. On the Bosphorus, however, observations in spring are scarce (Cramp and Simmons 1980). Between these two important migration routes, a third is across the Channel of Sicily. At various places along this route a great number of buzzards were counted. At Cap Bon, Tunisia, 8100 individuals moved between 2-18 May 1975 (Thiollay 1975, 1977). Other concentrations were observed in Malta (Beaman and Galea 1974) and on the Straits of Messina, in observations carried out between 1984 and 1990 (Dimarca and Japichino 1984, Agostini et al. 1990, 1991).

In the present study we examined the spring migration over the Straits of Messina. We document the migration route and examine the relationship between migration and atmospheric conditions. The Strait of Messina is 3 km wide at its narrowest point, southward it becomes wider. Migrating raptors have been observed from Capo dell'Armi to Palmi, but the most concentrated migration is between Reggio Calabria and Scilla (Agostini et al. 1990). A secondary migratory route occurs through the Aeolian (Lipari) Islands (Galea and Massa 1985, pers. observation).

STUDY AREA AND METHODS

Observations were made from 24 April to 28 May 1989 in the foothills of the Aspromonte Mountains on the Calabrian side of the Straits of Messina. The 40 km of coast where observations were made was divided in two sections, A and B (Fig. 1). In each section, three observation posts were chosen based on four years of observations to discover the route used by the buzzards. These observation points were on the slopes of the Aspromonte Mountains up to 5 km inland, and along the coast. The six observation posts were not used at the same time.

Each observation group was provided with 10×40 binoculars, telescopes, compasses, anemometers and maps of

the Military Geographical Institute (1:25 000). Two-way radios were used to avoid counting the same buzzards twice.

Each observation day was divided in three periods: morning 0740-1139 H, mid-day 1140-1539 H and afternoon 1540-1940 H. A total of 406.2 observation hours were tallied: 83.6 hr in section A and 322.6 hr in section B.

Hourly meteorological data for Reggio Calabria were provided by the Italian Air Force.

RESULTS AND DISCUSSION

The number of Honey Buzzards observed was 6057, 176 in section A and 5881 in section B. The average number of individuals counted per hour of observations in the two sections was 2.1(±0.6) and 18.2(±2.5), respectively. During the 35 d of observation the migratory flow showed three bouts of movement lasting 3 d each (Fig. 2). The bout of movement from 5-7 May included 59.9% of all Honey Buzzards counted.

The direction of the wind had a significant effect on the migratory flow ($F = 5.5, P < 0.01$). The prevailing winds in the period of the observation were from N, NE and SW. Ideal conditions for crossing the Strait existed apparently with N and NE winds. The average number of birds counted per hour of observation was 16.9(±3.6) with N wind, 30.2(±6.8) with NE wind and 2.4(±0.9) with SW wind.

When SW winds exceeded 35 km/hr, I observed the buzzards to fly low to the ground and to make an abrupt rise followed by a dive toward the ground. This seems to confirm that wind from SW, during spring migration, impedes the birds' flight. Decreased aerodynamic lift may slow the movement of air along the outline of the wings (Agostini et al. 1990).

Wind also influenced raptors during the long flights from Tunisia to Sicily. Crossing this part of the Mediterranean may present considerable hindrance to migration (Agostini et al. 1991). Unfavorable weather over the Channel of Sicily or at Cap Bon could be the reason for such variation in number of hawks counted. Raptors were uncommon over the Straits of Messina during unfavorable weather.

The analysis of weather reports from the Kelibia weather station indicates that in this area the relationship between the migratory flow and wind direction is complex. As compared with the Straits of Messina, the prevailing winds on the southern side of the Channel of Sicily during the observation period were from W, NW and E. This

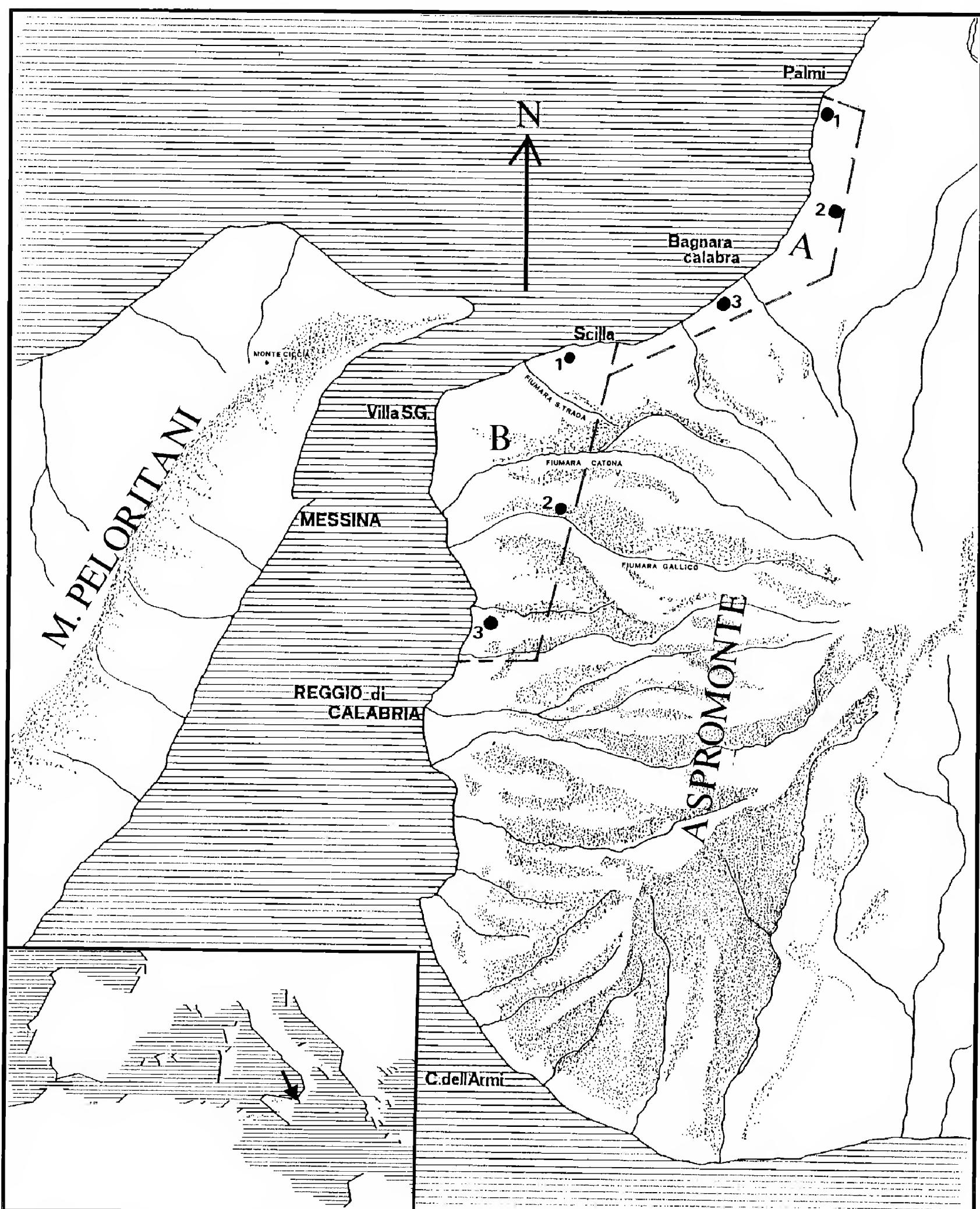


Figure 1. The location of the six observation sites in sections A and B on the Straits of Messina where migrating Honey Buzzards were observed.

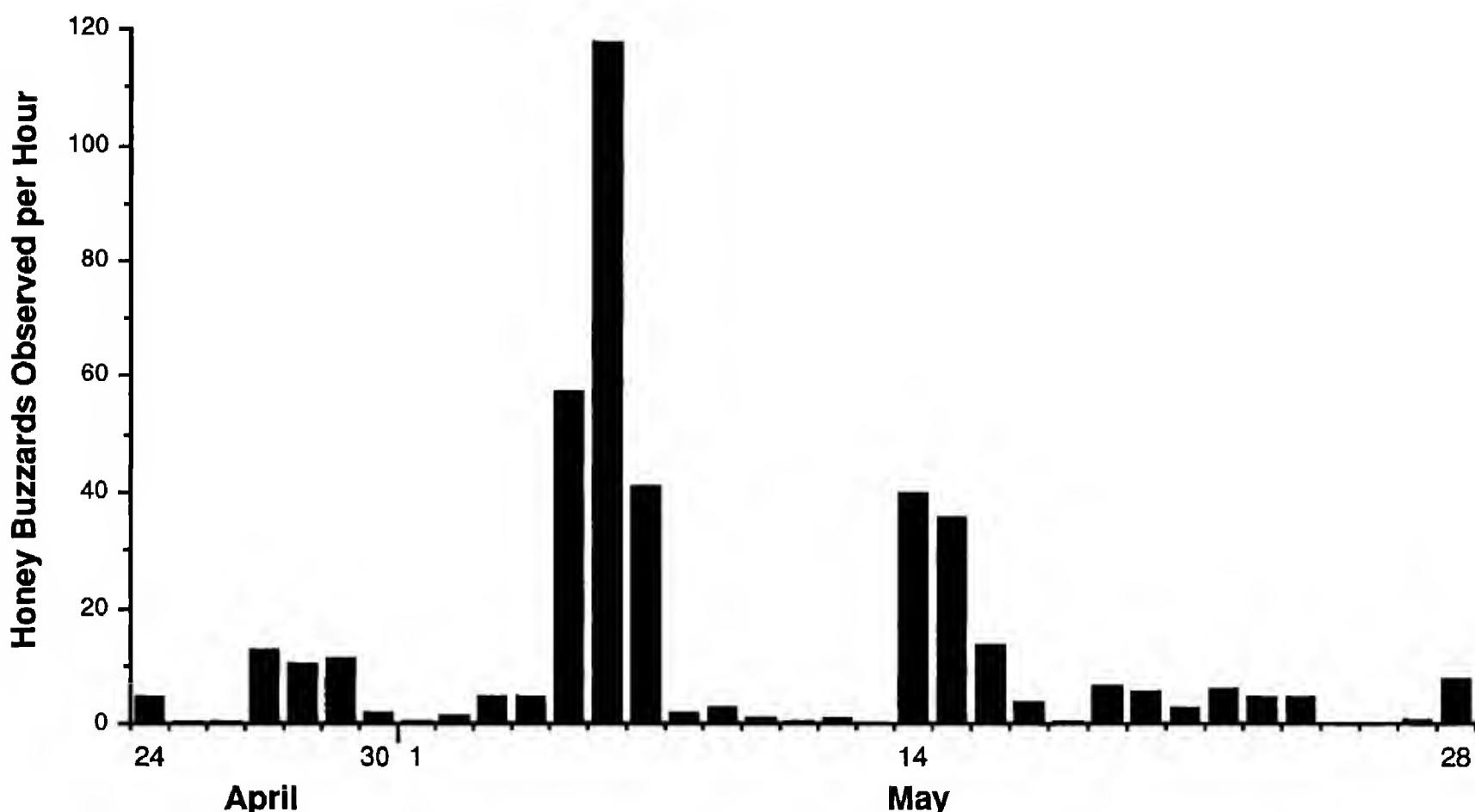


Figure 2. Seasonal occurrence of migrating Honey Buzzards at the Straits of Messina in spring 1989.

suggests that during crossings, the "drifting" by winds lateral to the migration direction could have a strong influence on migrants. Visual observations carried out at Cap Bon showed that buzzards crossed more often when lateral winds were weak (Agostini et al. 1991). This behavior was also noticed observing the migration of *Accipiter striatus* on Lake Superior. The author suggested that these birds preferred to cross when the possibility of being blown off course was low (Kerlinger 1984, 1985).

Therefore, during flight over the Channel of Sicily, it would not only be necessary to maintain a steady forward movement, but also to compensate for the deviation caused by such winds.

The migratory flow did not vary significantly throughout the day ($F = 1.9$, $P > 0.05$). The number of birds counted per hour of observation was $10.6(\pm 2.5)$ in the morning, $14.4(\pm 2.6)$ in midday and $16.0(\pm 5.9)$ in the afternoon. My observations confirm those of Dimarca and Japichino (1984) suggesting that raptors often precede a rain front. On 29 April, 63 buzzards flew south from observation site B1 after finding themselves between two storms, one west over Sicily the other northeast over Calabria.

Honey Buzzards migrated in flocks, sometimes as large as 200–250 individuals. On 463 occasions individuals merged into groups, accounting for a total of 5810 birds. On average groups were comprised of 12.6 individuals and 75% of groups contained fewer than 15 birds. On 235 occasions migrants flew alone. Forty-six interspecific associations were observed, mainly with Marsh Harriers (*Circus aeruginosus*) and Black Kites (*Milvus migrans*).

These were the two most commonly observed species except for the Honey Buzzard.

Once buzzards arrived on section B during their spring migration from SW or even from W or NW, they reached the mountains. The buzzards used powered flight, alternating with gliding, but on reaching the slopes they began soaring using thermals to glide inland toward NE. To approach the mountains, buzzards sometimes changed their direction. Moreover, both lone individuals and flocks were seen joining other birds of the same species in thermals. This was done from remarkable distances, even when the directions were sometimes opposed to the direction of migration (SW–NE). This seems to confirm that flock location can provide a clue for the location of the thermal currents (Kerlinger 1989).

On some occasions, groups split and used different thermals. It was not possible to quantify this because of poaching. Nearly 5000 rifle shots were counted. Raptors that were dispersed after the shots interrupted their approach toward the mountains and lost altitude. This exposed them more to the poachers' shooting. In response to shooting, we never observed, as noted by Cortone and Mirabelli (1984), that "... once one individual has been shot, the rest of the flock goes on wheeling in the same spot, not caring of shooting noise, without even trying to reach higher altitude . . ."

RESUMEN.—Se observaron 6057 *Pernis apivorus* a lo largo del lado de Calabria que da frente al Estrecho de Messina, al sur de Italia, entre el 24 abril y el 28 de mayo de 1989. Más del 85% de las migraciones se realizaron en 9 días,

con remarcable concentración de individuos (más del 50%) migrando entre el 5 y 7 de mayo. La mayor razón para la variación en el flujo migratorio parece que es la dirección del viento. Los vientos del norte y noreste facilitaron la migración, mientras que los vientos del sudoeste la inhibieron.

Estos *Pernis apivorus* se movilizaron en bandadas de 200–250 individuos, probablemente debido a la ubicación de las corrientes térmicas. Ocasionalmente, individuos aislados o en grupos se unían a otras aves, en alto vuelo, desviándose considerablemente de su dirección migratoria.

[Traducción de Eudoxio Paredes-Ruiz]

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LONG-EARED OWLS USURP NEWLY CONSTRUCTED AMERICAN CROW NESTS

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Long-eared Owls (*Asio otus*) use old nests of other birds (Marks 1986); however, I found no reports of Long-eared Owls using newly constructed nests of other birds. Here, I document three instances of Long-eared Owls usurping newly constructed American Crow (*Corvus brachyrhynchos*) nests, and three additional instances of owls nesting in close proximity to crows.

My observations were made during a study of crows near Minnedosa in southwestern Manitoba, Canada (Sullivan 1988, Sullivan and Dinsmore 1990). I found six Long-eared Owl nests in 1986, five in 1987, and one in 1988 while searching woodlots for crow nests during April-June. I made no special efforts to locate or monitor owl nests.

OBSERVATIONS

Nest Usurpations. On 29 April 1986, I saw two crows calling near a small, willow-fringed (*Salix* sp.) wetland. I found a nest on which a Long-eared Owl apparently was incubating eggs. I checked the vicinity of this nest daily, but did not observe crows at the site again until 6 May. On that day, the nest that had been occupied previously by the owl contained three crow eggs. I concluded that the nest had been constructed by crows during the current season; the nest contained twigs with freshly broken ends, indicating it was newly constructed (Good 1952). I also found white eggshell fragments, characteristic of owl eggs, at the base of the nest tree. I concluded that a predator had depredated the owl's clutch and that the crows had reoccupied their own nest. I observed crows near this site daily until 9 May. On 13 May, I found that the crow clutch had been depredated.

On 6 May 1987, I noted crow activity near another small, willow-fringed wetland. I found a newly constructed crow nest without eggs. Crows were in the area on 12 and 14 May. On 17 May, a Long-eared Owl flushed from the nest containing three owl eggs. I found no evidence of crow eggs being laid in this nest and concluded that the owls had usurped the nest before egg laying by the crows. The crows constructed another nest approximately 100 m away and laid a clutch that was subsequently destroyed by a predator.

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On 8 June 1988, I found a newly constructed crow nest in willows near a small wetland. I flushed a Long-eared Owl from the nest containing three newly hatched owlets and one egg. A pair of crows was nearby, calling and acting agitated. I thoroughly searched the surrounding woody cover to a radius of several hundred meters but did not find another crow nest.

Nesting in Close Proximity. In three separate instances during 1986 and 1987 I observed Long-eared Owls nesting in old crow nests at distances of 40, 35, and 5 m from attended crow nests. I observed no interactions between the owls and the crows during repeated inspections of the crow nests.

DISCUSSION

These observations seem to be the first published reports of Long-eared Owls usurping newly constructed nests of other birds. Where owls nested in close proximity to crows, one or more old crow nests were present in the immediate vicinity. Old crow nests were not present where usurpations occurred. Owls evidently will use old crow nests if available, but seemingly will usurp newly constructed nests if old nests are unavailable.

All usurpations of newly constructed crow nests took place before egg laying by the crows. There is a short interval (ca. 5 d) between nest completion and clutch initiation (Ignatiuk and Clark 1991), and crows are not as attentive to their nest sites before egg laying as they are later in the nesting cycle (pers. observation). Opportunities for nest usurpation by owls likely would be greatest before egg laying by crows.

Long-eared Owls also have been reported nesting within 50 m of crows in Saskatchewan, Canada (R.G. Clark pers. comm.). I found no reports in the literature of Long-eared Owl predation on crows (e.g., Bull et al. 1989). With the exception of occasional competition for nests, the lack of observed interactions between owls and crows nesting in close proximity suggests that these birds can coexist neutrally.

RESUMEN.—Entre 1986 y 1988 he documentado tres instancias en que búhos de la especie *Asio otus* usurparon nidos recientemente construidos por cuervos de la especie *Corvus brachyrhynchos* en el sudeste de Manitoba, Canadá. También documenté otros tres casos en que búhos de esta especie anidaron a una distancia entre 5 y 40 m. de nidos activos de estos cuervos.

[Traducción de Eudoxio Paredes-Ruiz]

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LETTERS

EDITORIAL: SHOULD SINGLE OBSERVATIONS BE PUBLISHED?

Observation of a single natural event can bias one's biological perception because the event may appear to occur more frequently than it actually does. Because the frequency of occurrence of an event is often equated with the event's biological importance, single observations have been given little credence in the scientific literature, especially by ecologists. This topic is especially pertinent for *The Journal of Raptor Research* because the aims of the Raptor Research Foundation, Inc., call for the study and conservation of all raptors, not merely those that are sufficiently abundant and accessible for intensive study. Consequently, *The Journal of Raptor Research* has published articles based on single observations. Reports of single observations may waste space in any scientific journal if a larger and more representative sample could be obtained with reasonable effort. However, there are several reasons why single events should be published on their own, or be mentioned as unusual occurrences when describing a more frequent event.

In some instances, events may be so rare that it requires many published reports of one event each for a concept to gain recognition. What biologist in her or his right mind would design a study of the rare use of rocks dropped by Ferruginous Hawks (*Buteo regalis*) presumably attempting to deter human intruders? One published record of this exists (C.L. Blair 1981, *Raptor Res.* 15:120). Would doubt of an event's existence linger in one's mind if the event could not be re-examined? Members of the French Academy of Sciences refused to accept the existence of meteorites for nearly all of the eighteenth century. Academy members chose to ignore reported sightings of falling meteorites because the fall was never witnessed by Academy members (B. Barnes 1988, *About science*, Basil Blackwell Inc., NY).

Another reason for taking seriously rare observations that may "occupy the valleys of concept topography," is because part of knowing what something is, is to know what it is not. If a behavior or character is truly rare in the biological world, this rarity itself has potentially important implications. The existence of an event, no matter how rare, indicates that genes and environment have made a match. The rarity of an event that nonetheless exists suggests that under currently existing selective scenarios the behavior or character has not been favored yet. It could represent the raw material for future evolution.

Another reason for taking rare events seriously touches on the potential limitations of the scientific way of knowing. Some very perceptive scientists encourage us to focus widely, not narrowly. According to them, the hypothetico-deductive method is one of many tools available to the scientist. K. Lorenz (1983, *Der Abbau des Menschlichen*, R. Piper and Co. Verlag, Munich, Germany) cautions that hypothesis testing can be akin to chickens pacing for hours trying to reach food close to them but behind a single panel of 10 m of fence. If the chickens were released some distance from the fence and saw the food from there, they would have a better chance to perceive a route around the fence than if they find themselves within touching distance barred by wire. T.S. Kuhn (1970, *The structure of scientific revolutions*, University of Chicago Press, Chicago, IL) suggests that contrary to the textbook's portrayal of reconstructed scientific progress, scientific understanding evolves in three stages that repeat themselves. "Normal science" occurs when hypotheses are tested, "extraordinary science" marks the appearance of unexplained anomalies, and "scientific revolutions" occur when old paradigms and theories are abandoned and reformulated into new ones to include anomalies. T.S. Kuhn makes much of the importance of anomalies. Anomalies can be rare in and of themselves, or only rarely perceived because they are not within the scientist's primary focus. Sometimes unusual events are only recognized as anomalies after one's conceptual framework changes (A. Lightman and O. Gingerich 1991, *Science* 255:690-695). For these reasons also, unusual events deserve to be described in detail.

In summary, one can defend the cautious use of single observations in enhancing biological understanding and justify their publication. Such observations can be important in furthering biological understanding, they can be a great source of inspiration for new ideas and they make for interesting reading. I thank Gary R. Bortolotti, Richard J. Clark, Michael Collopy, C. Stuart Houston and Cristoph Rohner for their helpful comments on this manuscript.—**Josef K. Schmutz, Department of Biology, University of Saskatchewan, Saskatoon, Canada S7N 0W0.**

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EVALUATING THE MERIT OF SINGLE OBSERVATIONS—RESPONSE TO SCHMUTZ

In reviewing the above editorial "Should single observations be published?", I initially supported the argument wholeheartedly. My intention here was to prepare a letter expounding the merit of single observations with examples gleaned from the pages of this journal. After reviewing all of the short papers from the Journal's first to last issue, I had to rethink my position.

One could argue that there is nothing inherently wrong with a publication with the ultimately small sample size, $N = 1$. A problem only arises in the interpretation of that information. At their worst, single observations tell us nothing about the biology of the subject and waste precious journal space. At best, they may suggest new lines of research, challenge conventional wisdom, and provide much needed information on the biology of little-known species. At very least, reports of natural history phenomena usually have the common denominator of being interesting reading. However, the economic reality of publishing a scientific journal such as *The Journal of Raptor Research* dictates that not all interesting observations can be committed to print. Given that, is there a way of separating the wheat from the chaff?

I suggest that potential authors should ask themselves a series of questions that might help them decide whether to report an observation (at least in a scientific journal; there are other avenues for publishing natural history notes). 1) Is the observation incomplete in any way (e.g., species identification, age or sex of the bird, location) that could potentially compromise the interpretation of the phenomenon? In other words, could there be something you either missed or did not know that could change the interpretation of the events? 2) Could the observation be the result of aberrant behavior caused by disease, toxins, human disturbance or captivity? In some cases, of course, the consequences of such factors are of interest; however, in others aberrant behavior may be well known and of little interest. 3) Has the same or similar phenomenon been reported before for the same species in other populations? Although, species x has never been seen to eat species y, it may not warrant publication if prey species a, b and c are known and similar to y. I consider many single accounts of food habits of Bald Eagles (*Haliaeetus leucocephalus*; we know they can eat just about anything), Ospreys (*Pandion haliaetus*) capturing mammals (yet another species caught is of questionable interest), and kleptoparasitism (known to be rather common for a wide range of species) to be redundant and hence unnecessary. 4) Can I get more data or combine data sets? Bird banders, or researchers with long-term projects, might want to delay reporting unusual events such as plumage aberrations, injuries and acts of predation (to name a few popular subjects) until more observations accumulate on the same or related topics. The publication of the collective effort results in a more effective and economical publication.

If you can answer "yes" to any of the above questions, think twice before you submit your paper. Finally, ask yourself "What could someone do with this information?" This is the tough one. If you can't think of a way that your observation could potentially be of value, then perhaps a non-scientific audience is preferable.—**Gary R. Bortolotti, Department of Biology, University of Saskatchewan, Saskatoon, Canada S7N 0W0.**

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HUNTING BEHAVIOR OF AUDUBON'S CRESTED CARACARA

Caracaras are well known scavengers and carrion eaters, and have been observed to kleptoparasitize other raptors, gulls and pelicans (W.C. Glazener 1964, *Condor* 66:162; L. Brown and D. Amadon 1968, *Eagles, hawks and falcons of the World*, McGraw-Hill, NY), but are also capable of hunting live prey. While foraging they fly close to the ground or perch on high observation posts for long periods of time. Their long legs and extended claws make them well suited for walking and running (J.N. Layne 1985, *Florida Wildl.* 39:40–42).

We observed Crested Caracaras from 7 June to 29 August in 1990, and from 10 June to 3 August in 1991 at the McArthur Agro-ecology Center (MAERC) of the Archbold Biological Station, a 4200-ha cattle ranch. The site consists of improved pastures, Cabbage Palm (*Sabal palmetto*) hammocks, native wetlands and Live Oak (*Quercus virginianus*) uplands. During the above mentioned period, adult caracaras still fed young that had fledged that year. We observed

two pairs that nested at MAERC. One pair had a territory in the northcentral region, and during both seasons was accompanied by three fledglings. A second pair was established to the south and was accompanied by two fledglings in 1990, and three in 1991. Observations were made from within a car, with the help of binoculars, whenever a caracara was observed perched by the roadside.

Of a total of 78 observations, 56 (72%) involved the northern pair and 22 (28%) the southern pair. Observations were biased toward the northern pair because they hunted within the limits of MAERC. The southern pair hunted in the southwest region of the ranch and on adjacent private land. Caracaras were perched on fence posts for 36% of the observations, and on Cabbage Palms for 18%. They were observed in flight 19 times; 6 (7%) in high transit flight and 13 (16%) in low, sweeping flights over open pastures. On 10 (12%) occasions they walked on a pasture and scanned and scratched at the base of grasses. On seven (9%) instances they fed on road-killed Armadillos (*Dasyurus novemcinctus*) and Raccoons (*Procyon lotor*), and on one occasion (1%) at the carcass of a domestic cow killed by lightning. While at the carcasses and on the fence posts, they were always with Turkey (*Cathartes aura*) and/or Black Vultures (*Coragyps atratus*).

While perched on fence posts, adults intently followed the activities of parent songbirds tending nests. Ground nesting birds were a focus, but birds in shrubs or trees were also watched. On two occasions caracaras watched Eastern Meadowlarks (*Sturnella magna*) arriving at the meadowlarks' nest in the pasture and then attempted to stalk them on the ground. After reaching the general vicinity where the meadowlark landed, they examined the base of grasses apparently looking for nests. We observed no successful raid on a meadowlark's nest. However, we did observe three successful raids of nests of tree-nesting Loggerhead Shrikes (*Lanius ludovicianus*) and one on a nest of Northern Mockingbirds (*Mimus polyglottos*). On all four occasions the caracara flew away from the nest tree with one or more nestlings in its beak. Although the mockingbirds followed the caracara, and screamed incessantly, they did not attack it. In contrast, both shrikes chased and attacked the caracara striking it mostly on the nape and back. The caracara twisted and turned in flight but did not release the young shrike.—**Reuven Yosef and Dalit Yosef, Department of Zoology, Ohio State University, Columbus, OH 43210, and Archbold Biological Station, P.O. Box 2057, Lake Placid, FL 33852.**

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MIGRANT PEREGRINE FALCONS IN NORTHWESTERN NORTH DAKOTA IN SPRING

Peregrine Falcon (*Falco peregrinus*) migration has been described for central Alberta (D. Dekker 1979, *Can. Field-Nat.* 93:296–302 and 1984, *Raptor Res.* 18:92–97). Few other published data exist on peregrines in migration through mid-continent North America, except for scattered reports in *American Birds* and routes implied by J.K. Schmutz et al. (1991, *Wilson Bull.* 103:44–58). Spring data are particularly scarce. Records of timing and areas used by peregrines migrating through this region may be valuable to manage the species in the United States and Canada, where it is currently listed as endangered or threatened (M. Martin 1979, Report to Committee on the Status of Endangered Wildlife in Canada, Environment Canada, Ottawa, Canada; U.S. Fish and Wildlife Service 1991, Federal Register 50 17–11).

Incidental to our other field studies during 1985–90, we made from one to several observations during each May ($N = 12$) of Peregrine Falcons at or adjacent to Lostwood National Wildlife Refuge in Burke and Mountrail counties, in northwestern North Dakota. The refuge consists of rolling mixed-grass prairie with 10–50 wetland basins/km². Migratory waterfowl and shorebirds are common to abundant in spring, and many remain to nest there (R.K. Murphy 1990, Vertebrate fauna of Lostwood National Wildlife Refuge, Refuge Publication, U.S. Fish and Wildlife Service). Peregrine Falcons are exclusively migratory in North Dakota, having been extirpated as a breeding species from the state in the 1950s (R.E. Stewart 1975, Breeding Birds of North Dakota, Tri-College Center for Ecological Studies, Fargo, ND).

We observed peregrines during 7–26 May ($\bar{x} = 27$ May, SD = 4.9 d), somewhat later than reported by Dekker (1979, 16 April to 30 May, peak 4–7 May for adults and 12–15 May for immatures) for central Alberta. All falcons we observed were in adult plumage. As Dekker (1979) noted, however, immature birds of the *F. p. tundrius* subspecies can be mistaken for Prairie Falcons (*F. mexicanus*) which are fairly common on the refuge in spring. We may have overlooked some immature peregrines. Two peregrines were observed together three times in 1990. We suspect two, and possibly all three, observations were of the same falcons. In all three cases the pair appeared to pursue prey

cooperatively, suggesting that they were a mated pair migrating together. Other observations were of single birds. Most (75%) peregrines were seen near or over large (20–100 ha), semi-brackish to saline wetlands. Four observations were of peregrines catching or feeding on prey including an American Coot (*Fulica americana*), Green-winged Teal (*Anas carolinensis*), White-rumped Sandpiper (*Erolia fuscicollis*), and Black Tern (*Chlidonias niger*). Another peregrine was observed stooping and scolding a nesting pair of Great Horned Owls (*Bubo virginianus*), as reported by C.S. Houston and K.A. Wylie (1985, *Blue Jay* 43:42–43). Peregrine Falcons rarely are observed in autumn on this refuge.

We thank J.H. Enderson for encouraging us to report these observations.—**Robert K. Murphy, Lostwood National Wildlife Refuge, RR 2 Box 98, Kenmare, ND 58746; Michael T. Green, Department of Biology, University of North Carolina, Chapel Hill, NC 27599.**

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A NORTHERN GOSHAWK NEST IN THE TUNDRA BIOME

The holarctic Northern Goshawk (*Accipiter gentilis*) is a bird of the forest and typically nests in a large tree in mature forest (P.S. Johnsgard 1990, *Hawks, eagles, and falcons of North America*, Smithsonian Inst. Press, Washington DC). It has been encountered well north of the treeline in Alaska in winter or early spring (L. Irving 1960, *Birds of Anaktuvuk Pass, Kobuk, and Old Crow: a study in arctic adaptation*, U.S. Nat. Mus. Bull. No. 217; A.M. Bailey 1948, *Birds of arctic Alaska*, Popular Series No. 8, Denver Mus. of Nat. Hist., Denver, CO) and nests in “white willow thickets” in the “forest-tundra” of the Soviet Union (G.P. Dementiev and N.A. Gladkov [Eds.] 1951, *Birds of the Soviet Union*, 1966 Israel Program of Science Translations, Jerusalem, Israel). However, nesting has not been previously reported for the tundra regions of North America.

We discovered a Northern Goshawk nest on 25 June 1985 145 km north of treeline at the confluence of the Oolamnagavik and Colville Rivers on the North Slope of Alaska (68°59'N 154°02'W, 150 m elevation). The nest contained one young about 15 d old and was defended by two goshawks in adult plumage. The young was flying well during the last visit to the nest on 25 July.

The nest was located 3 m up in a 5 m tall Feltleaf Willow (*Salix alaxensis*) in a willow stand covering about 100 ha. The tall shrub community of willows and occasionally Balsam Poplars (*Populus balsamifera*) is associated with large river drainages in the northern foothills of the Brooks Range. The numerous discontinuous stands of willows along the Colville River are surrounded by a vast expanse of open tundra. The willows at the confluence of the Colville and Oolamnagavik Rivers are among the tallest (up to 8 m) in the region (B. Kessel and T.J. Cade 1958, *Birds of the Colville River, Northern Alaska*, Biol. Paper No. 2, Univ. of Alaska, Fairbanks, AK).

Peregrine Falcons (*Falco peregrinus*) nested from 1980 to 1984 on a small bluff about 100 m from the nest site used by the goshawks in 1985. During 1985, the peregrines, individually identifiable by color bands, moved to a previously vacant bluff 2 km upriver. Normal movement by peregrine pairs between bluffs in this area is rare (pers. observation). The goshawks possibly displaced the peregrines from their usual nesting site. Goshawks were not found again during field searches of this area between 1986 and 1991.

Northern Goshawks occasionally hunt in open areas adjacent to woodlands (S. Cramp and K.E.L. Simmons [Eds.] 1980, *Handbook of the birds of Europe, the Middle East and North Africa* Vol. 2, Oxford Univ. Press, Oxford, U.K.) However, goshawks usually hunt from a perch (R.S. Palmer [Ed.] 1988, *Handbook of North American birds*, Vol. 4, Yale Univ. Press, New Haven, CT) and when hunting they frequently change perches (R.E. Kenward 1982, *J. Animal Ecol.* 51:69–80). The home range of a pair of goshawks, therefore, often includes numerous hunting perches as well as a suitable nesting site. The occurrence of isolated stands of willows and Balsam Poplars along major rivers of the North Slope provides at least marginal nesting habitat for Northern Goshawks in the tundra biome. The marginal quality of this habitat is suggested by the use of the territory for only one year and the production of only one young.

We thank Tom Bosakowski, Tom Cade, Jeff Hughes, Clayton White and an anonymous reviewer for helpful suggestions on the manuscript. The U.S. Bureau of Land Management and U.S. Fish and Wildlife Service provided funding and logistical support for our work on the Colville River.—**Ted Swem, U.S. Fish and Wildlife Service, 1412 Airport Way, Fairbanks, AK 99701; Macgill Adams, 3340 E. 150th, Anchorage, AK 99516.**

NEWS

Raptor Research Foundation, Inc. LIFE MEMBERS



EDMUND AND JUDITH HENCKEL
(Photo by Peter H. Bloom)

They are best described as a matched pair of jewels, one uncut hiding a precious gem within and the other a finely polished stone radiating its warmth to everyone within reach. If you have the great pleasure of making their acquaintance, you will soon know who is who.

Ed was born in Orange, New Jersey, on 21 September 1927. After serving as a first-class petty officer in World War II and the Korean War, he worked for 39 years as an electrician for the Delaware Lackawana Rail Transit. He drove Class X dragsters to become NHRA Eastern Champion. Later he switched to a more sedate source of propulsion, aloft in a hot air balloon. Ed has two children and a grandson from a previous marriage.

Ed's introduction to raptors came in 1967 when he began teaching outdoor education to boy scouts as Camp

Ranger at Camp Mt. Allamuchy in New Jersey. Here, Ed earned the Boy Scouts of America's prestigious Silver Beaver Award for distinguished volunteer service. During his nine year stint, "Ranger Ed" developed a deep and undying passion for birds of prey, especially for the much maligned vultures. Ed had a formidable impact in favor of raptors in New Jersey. He was the first "rehaber," formed the New Jersey Raptor Association and was the driving force behind the implementation of falconry regulations in this state.

Judith was born in Easton, Pennsylvania, on 29 January 1945. She has two children from a previous marriage, has participated in ski patrols, and loves gardening and photography. Although Judy once quipped that one of her goals is to amass the world's largest collection of raptor

jewelry, her main concern is promoting environmental awareness and conservation through raptor research and photography.

While earning a B.A. and an M.S. in biology from East Stroudsburg University, she monitored a Bald Eagle hack site in 1983, the first year of the program in Pennsylvania. Judy has brought a spark to the eyes of youths in 12 states with live birds and slide illustrated lectures, supported by the National Wildlife Federation. Judy was co-founder of Pennsylvania Raptor Rescue.

Both avid falconers, Ed and Judy were married in a ceremony at the 1980 meeting of the North American Falconer's Association in Alamosa, Colorado. Not far from their home in Mount Bethel, Pennsylvania, the Henckels operated a well-organized raptor banding station. Their considerable experience in trapping raptors and their "have RV—will travel" philosophy, adopted after Ed's retirement five years ago, has led to a full pallet of contracts in the western United States. The Henckels are involved in studies of the impact of contaminants on Bald Eagles in Alaska and Red-tailed Hawks in California, and studies of the use of home range by Northern Goshawks, Bald

Eagles and Swainson's Hawks in northern California. They also dedicate much effort to a long-term ecological study of Red-shouldered Hawks, Red-tailed Hawks, Cooper's Hawks, Barn Owls and Great Horned Owls in southern California, working with Pete Bloom, another life member of the Foundation. This intensive study focuses on breeding biology, food habits, mate and territory fidelity, contaminants, dispersal and habitat and home range use.

The Henckels have done a great deal over the years to allow the Foundation to stand for what it does today. Ed attended the first major meeting of the Foundation in Fort Collins in 1973 and has been missed during only one meeting since then. Judy has attended all meetings since she joined at a meeting in Tempe, Arizona, in 1977. The Henckels have participated in meetings on raptors in Greece and Israel and were particularly instrumental in organizing one of the many great RRF conferences in Allentown, Pennsylvania, in 1978. They have served on the Foundation's education and conference guidelines committees, and Ed served as secretary from 1982 to 1984.—Prepared by: David M. Bird, Peter H. Bloom and Debbie Keller.

Request for reprints on owls. Authors who wish for their articles or other publications dealing with owls to be listed in the second edition of a "Working bibliography of owls of the World" are asked to send reprints to: Richard J. Clark, The Owl Bibliography, c/o Department of Biology, York College of Pennsylvania, York, PA 17405-7199.

Publications available: **Birds in jeopardy:** the imperiled and extinct birds of the United States and Canada including Hawaii and Puerto Rico, by Paul R. Ehrlich, David S. Dobkin and Darryl Wheye. 1992. Send \$17.95 for paper or \$45.00 for cloth-bound copies to: Stanford University Press, Stanford, CA 94305. **Eagles: hunters in the sky,** a story-and-activities book tested by children in museum classrooms, and written by Ann Cooper. 1992. Send \$6.95 to: Roberts Rinehart Publishers, P.O. Box 666, Niwot, CO 80544-0666. **1991 Symposium on Peregrine Falcons** in the Pacific Northwest, edited by Joel E. Pagel. Send \$12 to: Rogue River National Forest, P.O. Box 520, Medford, OR 97501.

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The Journal of Raptor Research is distributed quarterly to all current members. Original manuscripts dealing with the biology and conservation of diurnal and nocturnal birds of prey are welcomed from throughout the world, but must be written in English. Submissions can be in the form of research articles, letters to the editor, thesis abstracts and book reviews. Contributors should submit a typewritten original and three copies to the Editor. All submissions must be typewritten and double-spaced on one side of 215 by 280 mm (8½ x 11 in.) or standard international, white, bond paper, with 25 mm (1 in.) margins. The cover page should contain a title, the author's full name(s) and address(es). Name and address should be centered on the cover page. If the current address is different, indicate this via a footnote. Submit the current address on a separate page placed after the literature cited section. A short version of the title, not exceeding 35 characters, should be provided for a running head. An abstract of about 250 words should accompany all research articles on a separate page.

Tables, one to a page, should be double spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be pencilled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (6th ed., 1983) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1990).

Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 24(1-2), which is available from the editor.

1992 ANNUAL MEETING

The Raptor Research Foundation, Inc. 1992 annual meeting will be held on 11-15 November at the Red Lion Inn in Bellevue (Seattle suburb), Washington. Details about the meeting and a "call for papers" will be mailed to Foundation members in summer, and can be obtained from Mark Stalmaster, Scientific Program Chairperson, Stalmaster and Associates, 209 23rd Avenue, Milton, WA 98354; Tel. (206)922-5435. For further information about the meeting, or the associated Spotted Owl Symposium and art show, contact Lenny Young, Local Committee Chairperson, 5010 Sunset Dr. NW, Olympia, WA 98502; Tel. O(206)753-0671 H(206)866-8039, FAX (206)586-6126.

RAPTOR RESEARCH FOUNDATION, INC., AWARDS

Recognition for Significant Contributions¹

The **Dean Amadon Award** recognizes an individual who has made significant contributions in the field of systematics or distribution of raptors. Contact: **Lloyd Kiff, 1100 Glendon Avenue, Suite 1400, Western Foundation Vertebrate Zoology, Los Angeles, CA 90024**. Deadline: August 15.

The **Tom Cade Award** recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. Contact: **Brian Walton, Predatory Bird Research Group, Lower Quarry, University of California, Santa Cruz, CA 95064**. Deadline: August 15.

The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor natural history. Contact: **David Andersen, Department of Fisheries and Wildlife, 200 Hodson Hall, 1980 Folwell Avenue, University of Minnesota, St. Paul, MN 55108**. Deadline: August 15.

Recognition and Travel Assistance

The **James R. Koplin Travel Award** is given to a student who is the senior author on the paper to be presented at the meeting for which travel funds are requested. Contact: **Michael W. Collopy, Department of Wildlife and Range Sciences, 118 Newins-Ziegler Hall, 0304 IFAS, University of Florida, Gainesville, FL 32611-0304**. Deadline: same as for abstracts.

The **William C. Andersen Memorial Award** is given to the student who presents the best paper at the annual Raptor Research Foundation meeting. Contact: **Keith Bildstein, Department of Biology, Winthrop College, Rock Hill, SC 92733**. Deadline: same as for abstracts.

Grants²

The **Stephen R. Tully Memorial Grant** for \$600 is given to support research, management and conservation of raptors, especially to students and amateurs with limited access to alternative funding. Contact: **James Enderson, Department of Biology, Colorado College, Colorado Springs, CO 80903**. Deadline: September 10.

The **Leslie Brown Memorial Grant** for \$500-1000 is given to support research and/or the dissemination of information on raptors, especially to individuals carrying out work in Africa. Contact: **Jeffrey L. Lincer, Eco-Analysts, Inc., 4718 Dunn Drive, Sarasota, FL 34233**. Deadline: September 15.

¹ Nominations should include: 1) the name, title and address of both nominee and nominator, 2) the names of three persons qualified to evaluate the nominee's scientific contribution, 3) a brief (one page) summary of the scientific contribution of the nominee.

² Send 5 copies of a proposal (≤5 pages) describing the applicant's background, study goals and methods, anticipated budget, and other funding.